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The status of the red panda in Jamuna and Mabu villages of eastern Nepal

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THE STATUS OF THE RED PANDA IN JAMUNA AND MABU VILLAGES OF EASTERN NEPAL

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ABSTRACT

THE STATUS OF THE RED PANDA IN JAMUNA AND MABU VILLAGES OF EASTERN NEPAL

by Brian H. Williams

The status of the red panda (*Ailurus fulgens fulgens*) is examined in the cultural context of Jamuna and Mabu Village Development Committees (VDCs) of the Ilam District in eastern Nepal. Intensive, market-driven land-use threatens red panda habitat and the largest unprotected oak stands in eastern Nepal. This study investigates red panda ecology and Jamuna and Mabu human ecology. Results indicate that red panda density in the study area average 1 red panda/1.38km^2, and they prefer undisturbed Eastern Himalayan mixed broadleaf forest between 2800m – 3000m. Predation is the greatest threat to the population. In the last year alone, local dogs killed two red panda. Results also indicate that Jamuna and Mabu land use decisions are market-driven with grazing and bamboo harvesting being the most detrimental to red panda habitat. This thesis concludes that, in Jamuna and Mabu, the red panda is critically endangered because of intense, market-driven use of its habitat and local dog predation.

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ABBREVIATIONS

CITES	Convention of the International Trade of Endangered Species
DBH	Diameter at Breast Height
H.C.F.	Hagetham Community Forest
H.C.F.C.	Hagetham Community Forest Committee
H.D.	Human Disturbance
HEDT	Himalayan Environmental Degradation Theory
HMG	His Majesty's Government of Nepal
ICC	Ilam Cultural Center
ICIMOD	International Center for Integrated Mountain Development
I.V.I.	Importance Value Index
J.C.F.	Jamuna Community Forest
J.C.F.C.	Jamuna Community Forest Committee
KMC	Kanchenjunga Mountain Complex
L.S.	Livestock Disturbance
LNP	Langtang National Park, Nepal
M.D.	Malingo Disturbance
Nrp	Nepalese Rupee
N.C.D.C.	Namsaling Community Development Center
PIS-corridor	Panchthar-Ilam-Singhalila corridor
PNHZP-SNP	Padma Naidu Himalayan Zoological Park-Singhalila National Park

R.R.A.	Rapid Rural Assessment
SNP	Singhalila National Park
VDC	Village Development Committee
WR	Woolong Reserve, China
WWF-Nepal	World Wildlife Fund for Nature-Nepal

GLOSSARY

Chauri: a yak/cow hybrid found in the Ilam uplands. They are valued for their thick milk and agility.

Chang: homemade rice or millet wine.

Churpi: a form of hardened cream sold in the international marketplace. The higher quality form is made from *chauri* milk.

goTH: temporary shelter used to house a rancher and their livestock.

goTHwalla: cattle or *chauri* herder that lives in a goTH.

Khukhuri: an angled knife used by Nepalese for cutting fodder, livestock, firewood, and bamboo.

Kipat: Limbu and Rai traditional communal land tenure system where villagers use all forest resources.

Lama: Buddhist priest.

Lekh: a highland area with winter snow.. In eastern Nepal it lies between 2200m – 3500m.

Lekhali cattle: local, highland cattle.

Malingo: *Arundinaria maling*, a ringal bamboo, the most common food source of the red panda in Jamuna and Mabu.

Ningalo: *Arundinaria aristata*, another ringal bamboo, the preferred food source of the red panda in Singhalila National Park. The second red panda food source found in Jamuna and Mabu.

Pill: 30 loads of firewood.

Pudhe Kudo: Local name for the red panda (*Ailurus fulgens fulgens)*.

Rakshi: handmade rice or wheat liquor.

Ropani: a Nepalese unit of land measurement. Twenty *ropani* are the equivalent of 1 ha.

I. INTRODUCTION

Importance

Since the agricultural revolution, humans have cleared large areas of land for their crops and homesteads. Each time a new plot of land was cleared, a piece of habitat, which housed numerous plant, animal, and insect species, was lost. Today, with the world's human population at over 6 billion, land and space are at a premium. Evidence of this epic land clearing can be seen on all continents, from the loss of rainforest in Central and South America, to the loss of fertile land for farming due to urban sprawl in the United States of America. As land is cleared, species decline and some become extinct. This loss of species, or biodiversity crisis, is one of today's major global environmental issues (Quammen, 1996; Wilson 1988).

Nepal's geographic location makes it a crucial link in South Asian biodiversity conservation. It lies between two geologically older biomes--the paleoarctics to the north and paleotropics to the south. Infiltration of biological species from both, and the mixing with indigenous ones, makes the country rich in all levels of its biodiversity (CBS 1998; Yonzon 1989). However, the country's expanding human population has cleared vast areas of forest to meet its needs.

In 1950, Nepal entered into the global economy by opening up diplomatic channels with western countries (Sharma 1995). Five years later, the United States and other European countries began the flow of foreign aid on which Nepal has become dependent. In the 1980's, foreign aid subsidies promoted land clearing in order to increase agricultural production (Devkota 1999). This fragmented forests and shrunk the amount of habitat available and many species and ecosystems became endangered. To combat this habitat loss, the Nepalese government began a protected area system.

Today, the protected area system conserves 15 % of all the land in Nepal (CBS 1998). Its least represented ecosystem is the Eastern Himalayan broadleaf forest. The status of one of its most elusive and endangered mammalian species, the red panda (*Ailurus fulgens*)[1], is unknown (Roberts 2001; Wikramanayake et al. 2001).

Protecting the red panda is important to both the preservation of Nepal's natural heritage and global biodiversity because it is a monotypic and indicator species with specialized food habits. It is unique in the animal world because it has no close living relatives and its family, *Ailuridae,* has only one genus, *Ailurus* (Roberts and Gittleman 1984). Like the spotted owl of old growth forests of the Pacific Northwest, the presence of the red panda indicates the amount and health of Nepal's Eastern Himalayan Broadleaf and Fir forests. Also, it is one of very few carnivorous species that have specialized for herbivory, specifically bamboo. Other than the red panda, there are only four other mammals, the giant panda, two bamboo rats (one in China and another in Brazil), and a small lemur in Madagascar, that are bamboo eaters (Roberts 1992). In Nepal, the exact distribution, population, and status of the species are unknown.

Only one field study of the red panda has been conducted in Nepal (Yonzon 1989, 1991). In Langtang National Park (LNP), Yonzon found three threats to red panda: habitat fragmentation, competition with livestock and humans, and predation by feral dogs. Further fieldwork is needed to assess the current status of the red panda in Nepal.

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[1] For the purposes of this study, "red panda" refers to the subspecies *Ailurus fulgens fulgens*.

This thesis provides information on the distribution of and human impacts to the red panda population in the Jamuna and Mabu Village Development Committees (VDC) of the Ilam district in eastern Nepal (Figure 1). Specifically, it describes red panda ecology and the way Jamuna and Mabu land use affects Eastern Himalayan broadleaf forest.

Background

Red Panda Ecology

The name "fire cat," the translation of *Ailurus fulgens,* is apt for the red panda. Its rich pelt ranges from light amber to deep auburn depending on the amount and angle of light. The first written report of this species comes from a 13th century Chou Dynasty scroll. However, it was not until six centuries later that Major General Thomas Hardwicke introduced it to Europeans. In his 1821 description to the Linnaean Society, Major General Hardwicke noted two names for the red panda, "Wha," because this was the sound it made when encountered, and "poonya," its name in the local dialect of the indigenous people from "the Himalaya chain between Nepaul and the 'Snowy Mountains' (maybe Sikkim)"(Roberts 1992). "Poonya" was then anglicized to panda, a word which today is commonly associated with the giant, black and white bear-like mammal. According to taxonomists, the red and giant panda are not related (Roberts 2001; Flynn et al. 2000; Chakraborty 1999; Johnson, Schaller and Hu 1988).

Appearance and Taxonomy. The red panda, a Himalayan member of Carnivora, resembles a raccoon in both size and appearance (Pradhan, Saha, and Khan 2001a; Roberts 2001; Wei, F. et al. 1999; Glatston 1994). It averages 100cm in length with its body being about 60 cm and tail about 40 cm long. Adult red panda in the wild weigh 4 kg (Yonzon 1989) while in captivity; they weigh 4 to 5 kg (Roberts 2001; Pradhan 1998; Yonzon 1989) (Figure 2). The red panda is of taxonomic importance because it is a monotypic subfamily, meaning that its subfamily, *Ailuridae* contains only one genus *Ailurus* (Chakraborty 1999; Yonzon 1989). *Ailuridae* has two subspecies, *Ailurus fulgens fulgens* and *Ailurus fulgens styani*, which split around 3 million years ago when torrential river flows cut the Eastern Himalaya forming the Brahmaputra Gorge (Chakraborty 1999; Wei et al. 1999). *A. f. styani* is distinguishable by its longer winter coat, larger skull, darker body color, and robust teeth (Wei et al 1999). There is still debate concerning the red panda's taxonomic placement. It has been placed in Procyonidae, Ursidae, Ailuropoda, and Ailuropodidae, but its fossil records, behavioral biology, anatomy, physiology, and reproductive habitats all point toward Procyonidae (Roberts 2001; Flynn et al 2000; Chakraborty 1999). Mitochondrial DNA studies examining allelic variation indicate that there are 3 red panda haplotypes, one in *A. f. styani* and two in *A. f. fulgens* (Choudhury 2001; Roberts 2001; Flynn et al. 2000).

Knowledge of red panda behaviour, feeding habits, distribution, habitat requirements and status in the wild is based on four studies: two in China, one in Nepal, and one in India (Pradhan, Saha, and Khan 2001a; Reid, Hu, and Huang 1991; Yonzon 1989; Johnson, Schaller and Hu 1988).

Behaviour and Feeding Habits. Adult pandas are solitary for most of the year but a male and female pair may forage together during the mating period from late January to late March, or there may be groups consisting of cubs and their mother

(Yonzon 1989). The gestation period is 112 to 158 days and a litter may have 1 to 4 young (Dittoe 1944; Roberts and Kessler 1979). The largest observed grouping of red panda in the wild was eight animals in Arunachal Pradesh (Choudhury 2001). This may have been a grouping of two mothers and their cubs (Choudhury 2001).

Cubs reach adult size at approximately 12 months of age (Bircher 1989). The red panda is arboreal and climbs trees using its sharp curved claws. It descends trees head first by gripping the tree bark with its hind feet (Yonzon 1989; Williams pers. obs.). Walking on the ground, it is inept and slow, which is when leopards and local dogs prey on them (Yonzon 2003; Williams pers. obs.). In captivity, their activity patterns vary (Roberts and Gittleman 1984) however, in the wild, distinct changes have not been noticed (Pradhan, Saha, and Khan 2001a; Yonzon 1989; Johnson, Schaller and Hu 1988). In the wild, the red panda is primarily crepuscular but forages for two hours in the mid-morning and mid-afternoon (Johnson, Schaller and Hu 1988; Yonzon and Hunter 1991). During inactive periods, it rests and sleeps mostly in trees. However, it has been observed resting in rocky outcrops and tree-hollows (Yonzon 1989; Pradhan 1998). The sleeping or resting position both in the wild and in captivity is curled-up with the head tucked under the hind leg (Yonzon 1989; Chakraborty 1999).

The red panda is an unusual member of Carnivora because it feeds mainly on bamboo leaves (Pradhan, Saha, and Khan 2001b; Wei et al., 1999; Yonzon and Hunter 1991; Reid, Hu, and Huang 1991; Johnson, Schaller and Hu 1988). In SNP, 83 – 92% of *A. f. fulgens'* diet consisted of bamboo leaves complemented during the monsoon with bamboo shoots, and fruits of various trees and shrubs (Pradhan, Saha, and Khan 2001b).

In the Wolong Reserve (WR), China, *A. f. styani* diet was almost identical consisting of 93.7% bamboo leaves supplemented with bamboo shoots, and fruits of various shrubs (Reid, Hu, and Huang 1991). In LNP, *A. f. fulgens* had the most diverse diet consisting of only 68% bamboo leaves complemented with succulent grasses, mushrooms, fallen fruits, insects, fungi, and grubs (Yonzon and Hunter 1991).

Distribution and Habitat Requirements. According to a 1994-1996 study of the Chinese red panda population, the red panda is now extinct in four of the seven provinces where it was once found (Wei et al. 1999). Today, it is patchily distributed in the Central and Eastern Himalaya of Nepal, Tibet, northern India, and Bhutan, and the high mountains of northern Burma, and the mountain ranges of western Sichuan and Yunnan provinces of China, with a disjunct population in the Meghalaya Plateau of northeastern India (Choudhury 2001; Wei, F et al. 1999; Yonzon 1989) (Figure 3). The reported western edge of its range is the Namlung Valley of the Mugu District in northwestern Nepal (Yonzon 1989). The southern edge of its range is the Liakiang Range in Western Yunnan, while the northern and eastern edge is the Upper Min valley of Western Sichuan, China (Wei, F et al. 1999). The subspecies *A. f. styani* is found only in China from the Hengduan mountains of western Sichuan south to the East Nujiang river in the Yunnan province (Wei et al. 1999). While *A.f. fulgens* is distributed east of the Namlung valley in northwestern Nepal, into the Tibetan Himalaya and the Gangshan mountains, northeastern India (West Bengal, Sikkim, Arunachal Pradesh), Bhutan, from northwest Yunnan to the southern Nujiang river (Choudhury 2001; Wei et al. 1999) (Figure 3). Throughout this range, the red panda is a habitat specialist that prefers subtropical and temperate forests between 1500m - 4800m, with the exception of Meghalaya, where it is found in tropical forests between 700m – 1400m (Pradhan, Saha, and Khan 2001a; Choudhury 2001; Choudhury 1997) (Figure 4).

In SNP, India, *A. f. fulgens* preferred Eastern Himalaya mixed broadleaf and conifer forests between 2800m - 3600m. The mean altitudinal distribution of this population was 3063m with a range from 2600m – 3600m, and a lowest reported sighting at 2400m (Pradhan, Saha, and Khan 2001a). In the WR, China, the range of *A. f. styani* was similar; here it used mixed coniferous and deciduous broadleaf and subalpine forests between 2600m -3100m (Reid, Hu, and Huang 1991). In LNP, Nepal, *A. f. fulgens* prefer fir-jhapra bamboo forests between elevations of 2800m - 3900m. However, within these forests the red panda has several microhabitat requirements; a dense understory of fallen logs, fruiting shrubs, and bamboo, and close proximity to a water source (Pradhan, Saha, and Khan 2001a; Wei, F et al. 1999; Reid, Hu, and Huang 1991;Yonzon 1989). In the WR, China, Reid, Hu, and Huang (1991) observed that *A. f. styani* requires dense bamboo thickets and many fruiting shrubs. Wei et al. (1999) noted that *A.f. styani* needs a high density of fallen logs and shrubs because it walks on them to gain easy access to bamboo leaves. Water is another important requirement of the red panda (Yonzon 1989; Pradhan, Saha, and Khan 2001a). In SNP, India, 79% of the plots with *A.f. fulgens* sign were 100m or closer to a water source, indicating that water is another important component of its microhabitat (Pradhan, Saha, and Khan 2001a).

Population and Status. The exact size of the world's wild red panda population is unknown due to the remote and rough terrain it occupies. However, the population is estimated to be 13,000 – 16,600 individuals, with 3,800 - 5,000 *A. f. styani* and 9,200 – 11,000 *A. f. fulgens* (Choudhury 2001; Wei et al.1999). The Chinese population is 6,000 – 7,600 individuals with 3,800 – 5,000 *A. f. styani* and 1,200 – 2600 *A. f. fulgens*. In the Sichuan province of China there are 3,000 – 4,000 *A. f. styani* individuals; while there are 1,600 - 2,000 in Yunnan province half of which are *A. f. styani*; in the Tibet Autonomous region there are 1,400 – 1,600 *A. f. fulgens* individuals (Wei et al. 1999). The Indian population is estimated at 3,000 – 4,000 *A.f. fulgens,* with the majority of them are found in Arunachal Pradesh, where they are considered fairly common (Choudhury 2001). The Nepalese, Bhutanese, and Burmese *A. f. fulgens* populations are estimated at 4,000 – 5,000 (Choudhury 2001).

In three studies of wild red panda populations, population density varied between 1 animal/1.67 km^2 to 1 animal/3 km^2 (Pradhan, Saha, and Khan 2001a;Yonzon and Hunter 1991; Reid, Hu, and Huang 1991). The densest population was in SNP, India, (1 panda per 1.67 km^2) followed by LNP, Nepal (1 animal/2.9 km^2) and the WR, China (1 animal/2-3 km^2) (Pradhan, Saha, and Khan 2001a; Yonzon and Hunter 1991; Reid, Hu, and Huang 1991).

The red panda is protected as an endangered species throughout its whole range and is listed in Appendix I of the International Union for the Conservation of Nature's (IUCN) Convention for the International Trade of Endangered Species (CITES) as EN C2a (red list 1996) (Choudhury 2001; Pradhan, Saha, and Khan 2001a; Wei et al. 1999). At the time of listing the world red panda population was thought to be (EN) endangered or facing a very high risk of extinction in the wild, (C) with a mature population of less than 2500, and (2) have a continued decline (observed, projected, or inferred) from, (a) severe fragmentation (subpopulations of less than 250 individuals). However, Choudhury (2001) reassessed the red panda world population status and asked that this listing be changed to EN A1c or (EN) endangered because of a (A) population reduction, (1) most probably 50% over the last 10 years, based on a (c) decline in occupancy and quality of habitat. To date no changes have been made in the IUCN CITES red panda listing.

In Nepal, *A. f. fulgens* is listed as a schedule 1 or top priority endangered species, facing threat of extinction, in the National Parks and Wildlife Conservation Act (1974) (Shrestha 1997; BPP 1995).

Eco-regional Conservation

In the past, biodiversity conservation focused on the creation of protected area systems. Today, older protected areas have become more accessible and insular, while newer protected areas are small and not large enough to create long-term species viability. Also, many of these protected areas were created for aesthetic, recreational, and political aims and fail to conserve biodiversity (Wikramanayake et al. 2001). Therefore, biologists are recognizing the need to move conservation actions outside of protected area and political boundaries into larger landscapes called eco-regions. This section discusses eco-regional conservation by outlining the biological vision and conservation priorities created for eastern Nepal. It focuses on the importance of the Eastern Himalayan Broadleaf forest, the preferred habitat of the red panda.

Eco-regional Conservation. An eco-region is the base of eco-regional conservation. It transcends national boundaries and, instead, focuses on meaningful biological boundaries that support distinct, major ecological and evolutionary processes which create and maintain biodiversity. It addresses ecological requirements by meeting spatial needs that maintain viable species populations, and anthropomorphic threats at multiple and temporal scales. Therefore, eco-regional conservation ensures long-term protection through representative regional biodiversity (Wikramanayake et al. 2001; Dinerstein et al. 2000). First, a regional biological vision is created. Then priority areas within the region are selected based on biological importance and landscape integrity.

Biological Vision. In 1999, the World Wildlife Fund for Nature-Nepal (WWF-Nepal) and International Center for Integrated Mountain Development (ICIMOD), two of the major players in Nepalese conservation, conducted a workshop on eco-regional conservation. The goal of the workshop was to create a vision of long-term biodiversity conservation for the Eastern Himalaya. Using WWF's Global 200 eco-regions as their base, they created a 50-year strategic plan (Wikramanayake et al. 2001). One of the critical eco-regions in this plan was the Eastern Himalayan broadleaf and conifer forest, the most underrepresented forest type in Nepal's protected area system.

Conservation Priority. The Kanchenjunga Mountain Complex (KMC), which contains Nepal's largest piece of unprotected, intact broadleaf and conifer forest, was targeted as a priority area. The central link in the KMC chain is the Panchthar-Ilam-Singhalila (PIS) corridor (Wikramanayake et al. 2001) (Figure 5). The 1999 expert committee of Nepalese and international conservationists ranked the PIS Corridor as a

Level I or highest conservation priority area based on its biological importance and landscape integrity. It received highest priority for two reasons: 1) it contains 660 km^2 of intact subtropical and temperate forests, which are fragmented or have been cleared in the rest of Nepal; and 2) it connects Singhalila National Park of Darjeeling to the Kanchenjunga Conservation Area, a tri-national reserve covering Northeastern Nepal, Northwestern Sikkim, and Southcentral Tibet (Figure 6).

Conservation of this corridor is important for 127 mammal, 490 bird, and 2,000 plant species (Wikramanayake et al. 2001). It would create an 11,500-km^2 area for focal species such as the red panda, clouded leopard (*Neofelis nebulosa),* bengal tiger (*Panthera tigris*), and himalayan thar (*Hemitragus jemlahicus*). The most endangered focal species in the PIS corridor, the red panda, is denser here than in other parts of its Nepalese range (Pradhan, Saha, and Khan 2001a; Yonzon and Hunter 1991). There is approximately 100 km^2 of habitat available in the PIS Corridor (Yonzon 2000). Therefore, using the SNP density figure of 1 animal/1.67km^2, the relative red panda population is 60 individuals.

Also, Inskipp (1989) states that this area is of immediate conservation importance for bird diversity. Thirty-four breeding species at risk in Nepal are found in the sub-tropical and broadleaf PIS Corridor forests. Fourteen endangered bird species, 8 of which were recorded in broadleaf forests outside of the Nepalese protected areas, are found in the PIS Corridor. In additon, the PIS corridor contains Nepal's most extensive Lithocarpus forests, which occur at the lower temperate elevations (2200m – 2400m) and localized Himalayan Yew (*Taxus wallichiana*) stands (Yonzon 2000).

This vision depends on participation and empowerment of the local people (Stevens 1993). Empowerment begins with the understanding of local people's perceptions of their environment. In the Bolivian Andes, Bastien (1978) identified Aymara indigenous belief systems and demonstrated how these beliefs are important keys to understanding complicated land use patterns (Bastien 1978). Managers can use the understanding of these systems to create effective long-term management plans. Taking into account the villagers' beliefs and needs encourages them to take more action in actively conserving their lands (Sherpa, Wangchuk and Mongar 1992). Understanding the reasons behind local land use decisions can create a powerful tool that future managers can use in eastern Nepal.

Threats to the Red Panda

In the biological vision of eastern Nepal conservation, the Eastern Himalayan broadleaf forest has the highest priority. The threats to this endangered ecosystem and its most prevalent focal species, the red panda, are human population expansion and commercialization.

Human Population Growth. In Nepal, during the 1950's, rapid human population growth occurred with the introduction of modern health care, medicine, and malaria suppression (Ives and Messerli 1989). The population increased from 8.5 million in 1952 to 18.5 million in 1991 (CBS 1998). The annual growth rate has remained above 2 percent since 1961 and the population is now at 23.7 million (UNEP 2001b; Chaudhary 2000; FAO 2000). This population explosion influenced the creation of the Himalayan Environmental Degradation Theory (HEDT)(Ekholm 1975, 1976; Sterling, 1976). The

HEDT states that most of Nepal's environmental deterioration, namely deforestation, is due to the Nepalese subsistence lifestyle. Forests provide villagers with wood for fuel, house shingles, timber for homes, fodder, thatch, farm tools, animal bedding, medicinal herbs, nuts, fruits, mushrooms, charcoal, and commercial construction timber (Ives and Messerli 1989). The red panda, being a forest dweller, is in direct competition with humans for these resources. In 1981, 90 percent of the population relied upon combustion of biomass for its energy needs (Ives and Messerli 1989). Little has changed with 14.5 percent of the current population living in urban settings and 85 percent of the rural population leading subsistence lifestyles (CBS 1998; UNEP 2001a). In 1998, 78% of the population still relied on the combustion of biomass for their energy needs (CBS 1998). Pressure for greater forest production has led to a conversion of forests into marginal scrublands. According to Chaudhary (2000), from 1964-1979, 400,000 ha of forest were cleared and converted to agricultural land or scrubland. Unlike the perspective held by aid agencies and conservationists, villagers view the forests as convertible resources needed for survival (Hrabovszky and Mijan 1987).

Commercialization. The increase in infrastructure, specifically roads, is influencing land use patterns in the middle mountains of Nepal. The most pronounced effect is an increase rate of market-oriented production (Brown and Shrestha 2000). More land is needed to supply Nepalese and Indian markets with milk, and crops like potatoes, tomatoes, and mustard (Brown and Shrestha 2000; Metz 1997, 1994; Yonzon and Hunter 1991). Most of the low lands are already in use and marginal village uplands are cut and converted into fields and pasture (Brown and Shrestha 2000; Metz 1997, 1994). Commercial milk production is the most detrimental to red panda habitat because, besides cutting existing forest, it increases livestock grazing, and firewood and fodder usage (Metz 1997, 1994; Yonzon and Hunter 1991). This land use change is common in many upper elevation villages, which border or are within red panda habitat. For example, the village of Chimkhola, located between 1550m - 4000m in west central Nepal, changed its traditional land use of corn, beans, and wheat production to grow more crops for market (Metz 1994). As a result, red panda habitat has declined and become fragmented.

Grazing and bamboo harvesting in marginal lands create another obstacle for the red panda—indirect competition for food. *Chauri*, a hybrid yak-cow, and cattle eat the lower meter of leaves and shoots on bamboo, leaving the least nutritious parts for the red panda (Yonzon and Hunter 1991). Bamboo is harvested for fodder, roofing, baskets, and for many other household items. Without it, life in marginal villages would end (Daniggelis 1997). In Bhutan, commercialization of bamboo extraction coupled with traditional use has created moderate to high species vulnerability (Messerschmidt et al. 2001). The moderate to high vulnerability of bamboo transfers to the red panda that depend on it for its survival.

Another danger for the red panda is dogs. In LNP, 57% of cub mortality was due to feral and rancher's dogs, which may be viewed positively by ranchers as red pandas compete with cattle for food (Fox, Yonzon, and Podger 1996; Yonzon and Hunter 1991).

Summary of Literature Review

A. f. styani and A. f. fulgens are biologically important because of their monotypic status and bamboo specialization. In Nepal, northeastern India, Bhutan, Burma, and China, they are found between 1500m – 4000m in forests with bamboo understory. Specifically, in the Eastern Himalaya, *A. f. fulgens* prefers moist broadleaf forests between 2800m –3100m. This forest is the focus of a new conservation initiative called eco-regional conservation with the red panda as one of its focal species. The Nepal/India border region, called the PIS corridor, is one of the priority areas. In this area, increasing population and commercialization have created overexploitation of marginalized land leading to a decline in red panda habitat, the Eastern Himalayan broadleaf forest.

Thesis Statement and Research Objectives

Purpose

Currently, insufficient information exists pertaining to red panda distribution and threats in Nepal. The purpose of the current study is to determine the status of and threats to the red panda within the cultural mosaic of Jamuna and Mabu Village Development Committees (VDC) in the Ilam district of eastern Nepal.

Objectives

To achieve this purpose basic ecological questions concerning red panda distribution, population, and microhabitat use, and sociological questions about the human ecology of

Jamuna and Mabu VDC's, including the cultural landscape, and land use, ownership, and management, are asked. These questions are summarized in the following outline:

1) Red Panda Ecology
   a) *Distribution and, Relative Population Size and Structure*
      i) Where are red panda distributed in Jamuna and Mabu VDCs?
      ii) What is the estimated red panda population in Jamuna and Mabu VDCs?
      iii) Is there a viable breeding population present in Jamuna and Mabu VDCs?
   b) *Microhabitat Structure and Use*
      i) What dominant tree and shrub species are found in red panda habitat?
      ii) What tree species do red panda prefer to use?
      iii) What physical and biological substrates do red panda use for latrines? Is there a temporal difference in substrate use?
      iv) What habitat or disturbance variables influence the presence or absence of red panda?

2) Human Ecology
   a) *Cultural Landscape*
      i) What is the settlement history of the study area?
      ii) What are the household and economic demographics of the study area? What are the similarities and differences of the household and economic demographics between villages in Jamuna and Mabu?

b) Land Use

i) What land uses are detrimental to red panda habitat and population?

ii) How are these land uses detrimental to red panda habitat and population?

c) Land Ownership and Management

i) What is the land ownership mosaic?

ii) What are the land management practices?

iii) What are the perceptions of the practices?

iv) What is the future plan for management and development of the area?

II. RESEARCH DESIGN

Overview of Data Collection Strategy

The main problem this research addresses is a lack of information about the distribution and threats to the red panda in Jamuna and Mabu VDCs of the Ilam District in eastern Nepal. Therefore, the field methodology was designed to provide an array of descriptive data focused toward answering the questions described in the last section. Basic ecological and forestry techniques were used to collect data on red panda distribution, micro-habitat structure, and population dynamics, while basic ethnographic and survey techniques were used to collect data on the Jamuna and Mabu cultural mosaic, and determine land use, ownership, and management. The comparison of red panda distribution, micro-habitat structure, and population dynamics data to previously published material can provide a clearer picture of red panda status in Jamuna and Mabu.

As a result, the ecological methods adapted were used in a previous study of the same red panda population (Pradhan, Saha, and Khan 2001a).

The ecological data collection methods used--altitudinal line intercepts (Sutherland 1996), the ten-tree plotless sampling method (Mueller-Dumbois and Ellenberg 1974), dung measuring and footprint surveys (Sutherland 1996)--provide information on different aspects of red panda ecology. The altitudinal line transects define distribution, while the ten-tree method describes microhabitat characteristics, and the dung and paw print survey indicate population dynamics. The ethnographical and survey data collection methods used--participant observation, formal and informal interviews, demographic survey and land use questionnaire--provide similar but complementary data about Jamuna and Mabu human ecology (Brown and Shrestha, 2000; Mehta and Kellert 1998; Spradley 1980). Participant observation was the base for the questions of the informal and formal interviews, demographic survey, and land use questionnaire, while the formal and informal interviews and demographic survey provided specific in-depth household and historical data and the land use questionnaire described local environmental perceptions. The combined ecological, ethnographic, and survey dataset elucidates different but complementary aspects of the problem of red panda conservation in Jamuna and Mabu.

Site Description

Himalaya. The word Nepal is associated with visions of Mt. Everest and towering snow capped mountains for good reason. It is the heart of the Himalaya, a 2,400km southerly arc from the Nanga Parbat (8125m) and Indus Trench in the west to Namcha Parwa (7755m) and the Yarlungtsangpo-Brahmaputra Gorge in the east, and the axis for the world's largest 'highland-lowland integrated system' (Gurung 1999, Stevens 1993, Ives and Messerli 1990). This towering 'abode of snow', its translation from Sanskrit, has a nine degree change in latitude and 22 degree change in longitude containing 31 peaks over 7600m (Gurung 1999). By dissecting this mass of mountains geographically, geologically, and ecologically, one can begin to grasp why this region contains a cultural mosaic unrivalled in the world.

Geographically, the Nepal section is called the Central Himalaya, however, several authors differ on its division. According to Mason (1955) and Bose (1972) the Nepal section spans from the Mahakali range in the east to the Singhalila range in the west. However, Spate (1957) described the Central Himalaya as Himachal Pradesh, Kumaon, and most of Nepal with eastern Nepal being a part of the East Himalaya. In Mason (1955) and Bose's (1972) studies they further divided the Central Himalaya into three sections the Karnali (Ghagra; Bose), Gandaki (Gandak; Bose), and Kosi. This study uses Spate's (1957) division; eastern Nepal is called part of the Eastern Himalaya.

Geologically the division runs from south to north. It begins with a slice of the Gangeatic plain called the Tarai, which contains a mass of alluvial sediments up to 5000m below sea level in places (Ives and Messerli 1990). Abruptly rising out of the Tarai plains is the foothills known as the Siwalik or Churia range. They contain schist and limestone and are the lowest and youngest members of the Himalaya family. The Himalaya proper follows with the Lesser Himalaya. This range, which has the same strike alignment as the Siwaliks, is higher and more complex with uplift contorting it into recumbent folds of old sediment over younger sediment (Gurung 1999). The climax, the Great Himalaya, consists of a crystal core of granites and gneisses with sedimentary remnants on its summits (Gurung 1999; Stevens 1993). Finally, the Himalaya are divided based on environmental variations.

The ecological division is separated by three variables, climatic, latitudinal, and zonal or altitudinal. Climate varies drastically with the southeast and east being humid and the west and northwest, due to the rainshadow cast by the wall of 8000m peaks in central Nepal, being arid (Gurung 1999; Ives and Messerli 1990). The 22-degree change in latitude along the Nepalese Himalaya causes the timberline to vary from 3400m – 3800m in the south to 4400m – 4800m along the Tibet Autonomous Region (TAR) in the north. The abrupt change in altitude creates drastic vegetation zone or zonal differences. One ridge may range from sub-tropical at the river valley to sub-alpine at its summit. The Nepali terminology for these zones is a reflection of this variability. The Tarai is called *madhes*, inner Tarai valleys, *dun*; hills, *pahar*; highland with winter snow, *lekh;* mounatins, *himal*; and trans-Himalayan valley, *bhot* (Ives and Messerli 1990; Stevens 1993). A village in the eastern mid-hills, like Jamuna or Mabu, usually contains *madhes, pahar,* and *lekh*. Land uses are influenced by the biogeographic regimes related to the zonal aspects of this vegetation.

Land use. The two general Nepalese land uses are transhumance and sedentary agriculture. Transhumance is related to the vertical zonation of resources. It allows for a mobile use of resources by the seasonal movement of people with animals from the highlands in the summer and fall to the lowlands in the winter and spring (Gurung 1999; Stevens, 1993). Sedentary agriculture, the maintenance of private farm or grazing land, is divided into lower, upper, and higher areas. The lower fields are usually irrigated terraced paddies for rice. The upper fields are outward sloping terraces traditionally planted with maize and millet. The higher area is common shrubland used for grazing (Gurung 1999; Mehta and Kellert 1998).

Jamuna and Mabu VDC's. Due to the Maoist insurgency, the initially proposed Taplejung and Panchthar study site was moved to the Ilam district. In October 2002, a preliminary search for the new study site revealed a population of red panda in the Jamuna and Mabu VDC forests. This site (88°59-88°02 East and 27°04-27°01North), which is roughly 12km^2, contains the largest contiguous pure oak stands in the Ilam district, was chosen as the study area (Figure 7, 8). Its north and south facing slopes are the Nepalese extension of the Singhalila range, which forms the eastern border of Nepal with India. Geographically the area is surrounded by the Mahabarat Lekh to the north, Jowbari ridge to the south, the Singhalila range, an international border and motorable road, to the east and the Mai Khola on its western edge. Politically, it is bordered by four VDC's--to the north is Mai Majhuwa, south is Pyang and Jogmai, and Mai Pokhari lies to the west--and Singhalila National Park, Darjeeling district, West Bengal, India to the east. There are ten villages present; those along the border road are called border villages while all other villages are called interior villages. The border villages are, from north to south, Kalpokhari, Kaiyakatta, Gairibas, and Jaubari, and interior villages are, once again from north to south, Dobato, Piple, Hagetham, Sisne, Nuntala, and Teenkharke (Figure

7). Politically, Jamuna comprises two thirds of the study area. Therefore, of the ten villages, eight (Gairibas, Jaubari, Teenkharke, Nuntala, Sisne, Hagetham, Piple and Kaiyakatta) are from Jamuna while only two (Dobato and Kalpokhari) are from Mabu (Figure 7). This *lekh* (highland) area, ranging from 1600m –3000m, contains a mixture of ethnic groups typical of upper elevation villages of mid-hill Nepal. Sherpa, Tibetans, and Bhotia, peoples with origins from the Nepalese Greater Himalaya valleys or Tibet, dominate the study area (Gurung 1999; Stevens 1993). Eastern Kirats, including Rai, Limbu, and Sunwar, and ethnic groups from other regions of Nepal, including Tamang, Gurung, Brahmin, Newar, and Damai, are also present (Daniggelis 1997). These peoples use two types of forest, Oak, 2200m – 2800, and Broad Leaf Deciduous, 2800m – 3100m, to survive (Shrestha 1988; Yonzon 1989).

Vegetation Zones and Composition. Two vegetation zones occur in the study area. Pradhan, Saha, and Khan (2001a) and Messerschmidt et al. (2001) give different names and delineations to these zones. Pradhan, Saha, and Khan (2001a) calls the 2600m – 2800m zone Oak Forest, and the 2800m – 3000m zone, Broad Leaf Deciduous Forest. Messerschmidt et al. (2001) call the 1800m – 2600m zone Evergreen Oak Forest, and the 2800m – 3000m zone Cool Moist Broadleaf Forest. This study's altitudinal range is 2400m – 3000m and will follow Pradhan's nomenclature; the 2400m – 2800m zone will be called Oak Forest, while the 2800m – 3000m zone will be called Broad Leaf Deciduous Forest.

In SNP, on the eastern side of the Singhalila ridge, the Oak Forest is composed of an upper canopy of *Lithocarpus pachyphylla* (81.2)[2], *Litsea sericera* (20.9) and *Magnolia campbelli* (17.1) with the sub-canopy dominated by *Litsea elongata* (55.0), *Schefflera impressa* (36.4), *Rhododendron arboreum* (32.0) and *Rhododendren griffithiana* (17.2) while the most common shrubs found were *Arundinaria maling*, *Vitex erubescena*, *Daphne cannabina*, and *Piptanthus nepalensis* (Pradhan, Saha, and Khan 2001). Bhutan's Oak forest is slightly different, with *Acer campbelii* and *Castanopsis sp.* dominating the upper canopy followed by *Quercus sp.* and *Pinus wallichiana* (Messerchmidt et al. 2001).

Singhalila National Park's Broadleaf Deciduous Forest was dominated by *Sorbus cuspidata* (49.6), Acer sp. (25.1), *Litsea sericera* (17.0), and *Quercus pachyphylla* (10.8) with the sub canopy being composed of *Symplocos sp.* (68.8), *Rhododendron arboreum* (33.3), *Osmanthus suavis* (23.47), *Rhododendron falconeri* (21.4), *Viburnum erubescens* (10.3), and *Meliosma delleniaefolia* (8.9) and the common shrubs were *Arundinaria maling*, *Arundinaria aristata*, *Vitex erubescense*, *Daphne cannibina*, *Rosa sericera*, *Piptanthus nepalensis*, and *Eltzostia sp.* The Broadleaf Deciduous Forest of Bhutan contain *Quercus sp.* and *Rhododendron sp.* with *Castanopsis* and other species in association with bamboos, shrubs, and ferns in the understory (Messerschmidt et al. 2001).

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[2] Numbers are based on the Importance Value Index from Pradhan, Saha, and Khan 2001a.

Climate. The seasons in Nepal follow the general pattern of 1) Winter (January – March), 2) Spring (April – June), 3) Summer (July – September), and 4) Autumn (October – December) (Yonzon 1989).

Eastern Nepal and the Singhalila Range demonstrate the classic monsoonal pattern and have more in common with Darjeeling and Sikkim than with central or western Nepal. Darjeeling's average annual rainfall is 3100 mm with 518 mm of this outside of the monsoon months (Polunin and Stainton 2000). In SNP, from 2400m – 2800m, the temperature ranges from 7- 17°C in the summer and 1-10°C in the winter, and, from 2800m – 3100m, average summer and winter temperatures are 7° and 1°C (Pradhan, Saha, and Khan 2001a). The mean average rainfall is 3500mm with an average humidity that ranges from 83-96%.

In the beginning of October the monsoonal rains taper off and cooler, clear days begin in the middle of the month. The days steadily become colder and Maple (*Acer sp.*), *Sorbus sp.*, and other deciduous hardwoods drop their leaves by the end of November or beginning of December. Misty damp days begin again and last until the first snow just in time for Christmas at the end of December. Above 2800m the snow will lay for weeks, especially on paths, roads, and shaded northern slopes. According to the local elders, 20 to 30 years ago snow would remain on the ground from December to February, a sign of recent increases in temperatures. The irregular snows will last well into March, with an occasional snow on Santukpur in April, when Chimal (*R. grande*) is in bloom. By mid-April early May, the temperate forests will peak with vibrant whites, yellows, pinks, and blood reds of Rhododendrons, Magnolia, and Symplocos. Middle May brings more and more clouds with daily afternoon showers beginning by early June. Mid-June monsoon proper arrives with mist and drizzle that won't lift until late September when the cycle begins again.

Human Ecology. Research into the human ecology of mountain peoples is based more on the Alpine and Andean experience than the Himalayan experience (e.g., Guillet 1983; Stevens 1993). Stevens (1993) distinguishes six adaptive patterns that apply to the Nepalese Himalaya: mixed mountain agriculture, agropastoral transhumance, scattered (multi-altitudinal) land holdings, communal systems of land tenure and resource-use decision making, private land and livestock holdings, and subsistence-oriented agropastoralism with other economic ventures (Stevens 1993). Many studies have described these adaptive patterns in terms of specific Nepalese ethnic groups without demonstrating how these patterns fit into the cultural mosaic of the middle hills (Pandey 1998; Daniggelis 1997; Stevens 1993; Subedi 1993; Fricke 1986). For example in a Rai dominated village, next to Makalu-Barun National Park, mixed mountain agriculture, subsistence oriented agropastoralism, and portering are the dominant activities (Subedi and Pandey 2002). Two Brahmin dominated villages of Ilam demonstrated generational coping strategies (Subedi 1993). While Khumbu Sherpa combined subsistence oriented agropastoralism and transhumance with portering and other economic ventures tied to tourism to cope with their extreme environment (Stevens 1993). By focusing on one or at the most two ethnic groups the above mentioned researchers were able to identify the decisions and patterns of land use of one particular group with a specific set of cultural norms and environmental variables. The mid-hills, a matrix of villages containing complex mutli-ethnic interrelationships, do not adhere to these simplified cultural norms and environmental variables. The Ilam district and Jamuna and Mabu VDCs in particular are relevant examples of this mosaic with Gurung, Rai, Limbu, Tamang, Sherpa, Sunwar, Damai, Newar, Brahmin, Tibetan, and Bhotia being represented (NCDC 1998). These peoples have adopted mixed mountain agriculture, private land and livestock holdings, agropastoral transhumance, and subsistence agropastoralism with other economic ventures to survive the varied and difficult Nepalese mid-hill environment.

Components of Research

Red Panda Distribution

A weeklong preliminary survey of the Jamuna /Mabu study area, from October 20 –27, 2002, confirmed the existence of red panda with a sighting and scat finding near Dobato (Figure 8). In mid-November 2002, the ecological census began and it lasted 67 field days until mid-March 2003, with several breaks due to Maoist rebel movement in the study area. The census was conducted by using altitudinal line intercepts, during which local villagers were also interviewed to provide complementary information on red panda distribution.

Altitudinal line intercepts. A line intercept is a basic ecological technique used to survey species distribution. To conduct a line intercept, a line is laid in the study area.

The number of times the animal is sighted or sign of the animal is observed on the line is recorded. These points are then marked on a map to demonstrate the area covered by the species (Sutherland 1996).

For this study, altitudinal line intercepts were used to record red panda distribution. Using a Garmin Etrex Vista® GPS and a His Majesty's Government of Nepal (HMG) 1:25,000 survey map as altitudinal guides, seven altitudinal lines, one every 100 meters, were surveyed following contour lines corresponding to elevations from 2,400m – 3,000m (Figure 7). The 2,400-meter mark was used as the starting line, because this was the lowest altitude a red panda was observed in LNP, Nepal (Yonzon 1989). The 3,000-meter mark was used as the ending line because the study area's highest point (Mane Danda: south of Kalpokhari along the border at the crest of the Lalbas Danda ridge) is 3080m. Panda presence was measured by recording the latitude and longitude of indirect (pawprint, scat) direct (sighting) red panda sign with the Garmin Etrex Vista® GPS and marking these points on the HMG 1:25,000 topographical survey map (Figure 2, 9, and 10). These data were then entered into ArcView GIS 3.1 software to create a distribution map.

Interviews. To conduct the line intercepts the researcher and his assistant had to stay in different parts of the study area. In the southern half of the study area, they stayed in Hagetham, Gairibas, and Jaubari, while in the northern half they stayed in Dobato, Piple, Kaiyakatta, and Kalpokhari (Figure 8). In each place, local villagers were interviewed about past sightings. First villagers were asked questions to probe their knowledge about the local fauna, like "*Tapaile kun kun januwar deknubaiko cha*?" (What animals have you seen?). If the informant seemed knowledgeable about local fauna then specific questions about the red panda, locally called *pude kudo* or white face, were asked. This second round of questioning focused on past sightings and known habitat. The informant was first asked if they had seen a red panda, and if they had, questions were focused on the specifics of the past sighting including the time of year, location, time of day, and number of animals. If they had not seen a red panda, then questions were asked regarding possible locales where others commonly see red panda. This information was then labeled on the same survey map used in the ecological census.

Red Panda Population Structure

Scat measurement and Paw print survey. In LNP, Yonzon (1989) used snowtrack and pellet size to determine the age of red panda. Yonzon (1989) noted that there was "an obvious difference" between a mother and cub snowtrack, with the mothers being larger. Also, Yonzon (1989) found a significant difference between the length and diameter of adult and cub pellets. Adult pellets averaged 19.2 ± 2.3mm and 41.6 ± 6mm in diameter and length while those of young were 14.9 ± 2.6mm and 34.7 ± 7.1mm.

For this study, a scat and paw print survey were conducted to determine the presence or absence of a breeding population (Yonzon 1989; Sutherland 1996). From January to March, 2003, the paw print survey was performed during three snowfall events in which paw print width and length were measured. The scat survey was conducted during January, and scat diameter and length of 158 pellets was measured in six plots. Yonzon's (1989) pellet figures were used to distinguish between adult and cub scat. Both scat and paw prints were measured using the Sunto® Tandem compass and clinometer.

Microhabitat Assessment

Plotless and quadrat sampling methods were used to assess micro-habitat characteristics and use including estimate density, dominance, frequency, and importance value of trees and shrubs, and red panda tree and substrate usage (Sutherland 1996). Importance value determines the overall contribution of a plant to a community by comparing the combined density, dominance, and frequency, relative to other species in the community (Appendix 1).

Ten-tree plotless sampling. The ten-tree method is a nearest-neighbor sampling method that involves creating a plot from the closest eleven trees encircling a center point (Mueller-Dombois and Ellenberg 1974). Plot area is derived by measuring the distance from the center point to the tenth and eleventh tree, averaging these measurements, and using the averaged number as the radius of the circle (Mueller-Dombois and Ellenberg 1974; Pradhan 2001).

In this study, two types of plots were measured using this method: plots where red panda sign was found and random plots. Both direct sighting and indirect evidence (scat) were considered to be sign. After approximately ½ km of hiking along the altitudinal line transect, if red panda sign was observed then the observed substrate was used as the plot center and a panda sign plot was measured. If no red panda sign was observed, a random plot was selected using a random number table (Table No. 33 Fisher and Yates). The plot center point was determined by pacing the randomly chosen number and direction and a random plot was measured.

Panda sign plots were measured in two ways: If 100 pellets of scat or more were observed, then canopy cover, slope angle, altitude, aspect, habitat, topography, ten longitude and latitude points, tree diameter at breast height (DBH) and species for all eleven trees, substrate used (if the substrate was a tree its species and DBH), number of pellet groups, and pellets per group plus comments were recorded. Canopy cover was measured by eye, while slope angle and aspect were measured using a Sunto® Tandem compass and clinometer, and tree DBH was measured using an INDEX 50m measuring tape. If fewer than 100 pellets of scat were present, then canopy cover, slope and the eleven tree DBHs were omitted. At random plots, canopy cover, slope angle, altitude, aspect, habitat, topography, ten longitude and latitude points, tree DBH and species, and comments were recorded. In both random and panda sign plots, three degradation variables, livestock (L.S.), human (H.D.), and malingo disturbance (M.D.), were also measured (Table 1).

Quadrat sampling. To measure bamboo, shrub, and understory species density, cover, and frequency, a 3x3m quadrat was established for every random and panda sign plot (Pradhan, Saha, and Khan 2001a; Shrestha 1988). A random cardinal (North, East, South, or West) direction was chosen using a random cardinal direction table. The 3x3m quadrat was then placed away from the plot center point in the chosen direction (North, East, South, or West). Number, type and cover of shrub species, number, height, and cover of bamboo species, and understory species and cover were recorded.

Ethnographic Research

Ethnographic data was collected through two methods: participant observation and interviewing (Spradley 1980). Participant observation, which is less intrusive because the researcher watches subjects in a familiar, comfortable setting, provided the basis for informal and formal interviews (Spradley 1980). From November 2002 to March 2003, in conjunction with the ecological census, these complementary qualitative methods were used to focus on the identification of local land use strategies. Then, from April - May 2003, semi-structured interviews were conducted to identify land use locales and clarify land use strategies.

Participant Observation. Participant observation is a basic technique used in ethnographic research. It allows both the researcher and subject to become comfortable with each other, is used to interpret cultural subtleties, and provides themes for informal and formal interviews (Spradley 1980). It has been used in other studies of man-environment interactions in the Himalaya (Pandey 1998; Daniggelis 1997; Stevens 1993; Subedi 1993; Fricke 1986).

From 1996-1998, the researcher lived and worked as a Peace Corps volunteer in Prangbung, Panchthar, 20 km north of the study area. The Peace Corps Nepal program emphasized cultural exchange similar to participant observation. Volunteers were trained to integrate into Nepalese culture by observing and doing village activities. Using this training, the researcher learned how to distinguish different land uses, like cutting firewood and fodder. Also, the researcher traveled through Ilam to get in and out of

Prangbung, creating a base of informants for the current research. In October 2002, the study area was found with the help of these informants. From November 2002 – February 2003, Jamuna and Mabu villagers were observed to understand local land use and identify land uses that affected red panda habitat. While performing the ecological census, observations were conducted in villages and the forest. Villagers were observed doing their daily activities like feeding cattle or cutting firewood. All observations were written in a field notebook and used to develop topics for informal and formal interviews. These observations identified six main land uses--livestock grazing, firewood, timber, bamboo, and fodder collection, and hunting--hat are detrimental to red panda habitat. In order to determine the impact of these land uses on the eastern Himalayan broadleaf forest, informal and formal semi-structured interviews were conducted from April to May 2003. The methodology used during these interviews is described below.

Interviewing. In oral societies, like Nepal, formal and informal interviewing can unearth more information than document research. For this reason, these techniques have become important tools for conducting ethnographic studies (Spradley 1980). By nature, informal interviews are conversational and unstructured but centered around a broad topic, while formal interviews are structured and focused to gather specific information. Combined, these techniques provide a holistic approach to collecting data on cultural phenomena. In this study, informal interviews provided the basic topics from which formal semi-structured and structured interviews were developed.

For the first month in the field the researcher became aquainted with the web of relationships present in the study site. Local villagers were curious about the study and asked many questions about red panda and forests. These questions created a natural transition into other subjects like land use, community forestry regulations, attitudes toward biodiversity conservation, development, and land ownership and management. After many hours of conversation in front of the fire with different people and families, key informants were chosen for semi-structured interviews that included both group and one-on-one interviews.

Semi-structured sketch map interviews are one of the tools used in 'social forestry' (Fox 1989). According to Fox (1989), sketch maps are the most appropriate technology for understanding land use practices and conflict. The aim of this technique is to elucidate land use practices of farmers through a set of topically semi-structured interviews, which use a sketch map as their basis. The topics of the interviews conducted focus on physical/socio-economic environments, agricultural and horticultural practices, livestock management and forest land use.

For this research, sketch map interviews focused on forest land use, as well as attitudes toward biodiversity conservation, forest regulations, and community forestry (Fox 1989; Mehta and Kellert 1998). To create the sketch maps the researcher redrew and enlarged the grid cells of a HMG 1996 1:25,000 topographical survey map on a blank sheet of newsprint paper. In April and May, four sketch map group interviews were held in Jaubari, Kalpokhari, Dobato, and Hagetham. At each interview, except in the case of Hagetham when Hagetham Community Forest Committee (H.C.F.C.) members attended, 5 local residents, including one female, labeled and identified physical objects such as rivers, roads, schools, houses, farmland, grazing land, National Forest, and trails on the blank maps. Then interviewees identified and labeled forest land uses. Each land use was given a symbol and the symbol was drawn in the area where the activity occurred. During map drawing, a friendly tone was set for the meeting by inquiring about local participants' families and crops. The interview began after all land use locales were labeled. Using the map as a guide, questions pertaining to each land use were asked. Each interview was taped and transcribed for accuracy.

After the completion of each sketch map interview, follow up one-on-one interviews were held with key informants. These informants included local leaders, teachers, businessmen, women, and farmers. Interviews were taped and some answers recorded during (or five to ten minutes after) the interview was completed. Interviews focused on the six main land uses, land ownership and management, the H.C.F.C., the Ilam district forest office, development, the local economy, and settlement history. To create unbiased reponses questions were left open-ended. Questions were broad at first and then asked about specific topics as the interview proceeded. For land use information, Nima Pinju Sherpa was the most valuable. In the field, Nima answered repeated questions about bamboo cutting and regrowth, firewood and timber cutting, hunting, and grazing. To create Jamuna and Mabu settlement history, elder villagers described landmark events. Prithvi Man Tamang, Tukten Lama, and T.N Bhattrai were particularly knowledgeable in Jamuna village development, while Bazanee Rai and Pasang Sherpa provided the information on Mabu village development. Each was asked "Gadiko bato kahile banaunubaiko tyo?" (When was the road built?) and "Alu bikas kati barsakolagi lagako tyo?" (How many years did the potato development program last?).

The intricacies of local land ownership and management were desribed by Pemba Sherpa, Nima Pinju Sherpa, and the members of the H.C.F.C. While Ram Takur and Bijay Raj Paudyal provided information about the Ilam district forest office. Lastly, G.T. Lama provided information about the local economy. These interviews provided one perspective of Jamuna and Mabu land use, settlement history, land and forest management, economy, and development. Therefore, a household demographic survey and land use questionnaire were conducted to create a more balanced view of these topics with three differing perspectives (Grandstaff and Grandstaff 1987).

Survey Research

Surveys provide specific quantitative information that can be analyzed to answer a set of predetermined questions. They have been used in other studies of mid-hill Nepal to assess land use dynamics and local attitudes toward conservation (Brown and Shreshta 2000; Mehta and Kellert 1998; Kennedy and Dunlop 1989). From May to June 2003, two surveys--demographic and land use--were conducted to obtain complementary quantitative data on Jamnua and Mabu land use and management, the economy, and development. The demographic survey followed Mehta and Kellert (1998), while the land use questionnaire followed Brown and Shrestha (2000).

Demographic Survey. In Makalu-Barun National Park, Nepal, local attitudes toward conservation were dependent on demography (Mehta and Kellert 1998). With this in mind, a demographic survey for this study was developed to collect data about household demographics and land use. Households from the 10 villages surrounding the study area were selected for the survey (Figure 7). At each household, the number of household members, ethnicity, age, education level, land owned (*ropani*), number of livestock, monthly expenses, type of roof, monthly firewood usage, monthly bamboo usage, and number of dogs, were recorded. These data were entered into an Excel™ spreadsheet to analyze trends.

Land use Questionnaire. Using a land use questionnaire, Brown and Shrestha (2000) found that market-oriented production influenced land use in the Nepalese mid-hills. The same approach was applied to the 10 Jamuna and Mabu villages to discover the level of itensity of fodder, bamboo, firewood, and timber usage, and to document income sources (Appendix 2). First the land use questionnaire was tested on several villagers after which it was translated into Nepali and administered to every household in the 10 villages. Responses were tallied and entered into SPSS version 10.0™ for analysis. The study area was divided into north (Dobato, Kalpokhari, Piple and Kaiyakatta) and south (Hagetham, Gairibas, Jaubari, Nuntala, Teenkharke, and Sisne) to create a 33/67 split for the statistical analysis (Figure 7). Cross tabulations, and chi-square and t-tests were then performed on the data based on the north and south study area split.

Limitations

The remote nature of the study site limited communication and access to electricity and proper equipment. At the beginning of the study, there were four available phones, three in Nepal and one in India. After three months, Maoist rebels stopped communication from the three Nepalese phone lines. This made it impossible to consult in-country or out-of -country advisors, leading to methodological mistakes in the ecological census and land use questionnaire. Also, the rugged terrain made it difficult to complete the altitudinal transects leading to biases in the ecological census. The lack of electricity slowed the pace of research because all measurements had to be entered twice. The use of a palm pilot or computer would have solved this problem. Canopy cover measurements were less accurate because the researcher did not have a spherical densiometer.

This study's combination of ethnographic, geographic, and ecological concepts creates both richness and limitations. It allows for broader interpretation of results but limits the amount of detail of those interpretations. For example, more in-depth questions about red panda ecology or Ilam cultural ecology could have been answered.

According to Spradley (1980), ethnographic studies always have some degree of cultural bias. Differing cultural norms and values influence participant reactions to the researcher. Another researcher conducted red panda research in the study area but received a totally different response from participants. A person with strong community ties introduced him to the study area and some villagers divulged information unknown to the author.

III. RESULTS

Red Panda Ecology

Red Panda Distribution

Sightings by villagers. According to local sightings, red panda use the montane oak and mixed broadleaf forests between 2200m and 3000m. This area is almost directly related to the distribution of their food source, *malingo* (*Arundinaria maling*). It extends from Kalpokhari in the northeast to Jaubari in the south over to Nuntala in the southwest sweeping north above Hagetham through Piple and ending at Dobato in the northwest (Figure 7). During the survey, red panda were observed by villagers in Kaiyakatta, Jaubari, Piple, Dobato, and Gairibas. The villagers from Piple, at 2200m elevation (Figure 7), stated that they had seen red panda in the trees around their homes. When asked about the frequency of this occurrence they remarked that it only happens once or twice a year. Villagers in Jaubari and Kaiyakatta observed the red panda 4 times in each location from November 2002 to May 2003. In Dobato several locals observed red panda more than once. One local stated, " I saw it jump from the tree and walk on the ground over into the National Forest." This encounter occurred at the northwestern corner of the study area and appears to be a corridor from a small patch of mature forest on the sunny southern slope over into the National forest on the northern slope of the ridge. In Gairibas locals observed red panda crossing the trail one km south of the village on the Gairibas-Jaubari trail (Figure 7). However, other than the occasional observation around

Piple, the sightings all took place at or above 2600m, which coincides with the ecological census results.

Indirect observations. In the ecological census, red panda sign was recorded between 2500m - 3000m (Figure 11). From 2400m - 2600m, red panda sign was observed at a rate of .56/km. At the 2600m -2800m range, it was observed at five times the 2400m – 2600m rate at 2.44/km. At the last altitudinal range, 2800m - 3000m, red panda sign observance doubled the previous ranges rate at 5.1/km (Table 2). This distribution of red panda sign indicates that red panda are relatively more abundant in the 2600m - 3000m range and that they are most dense in the 2800m –3000m range.

The actual amount of scat observed per day is another key indicator of red panda distribution. The encounter rate of pellets per day shows a dramatic difference in the relative abundance of red panda scat. At 2400m - 2600m the rate is 7 pellets per day, while at 2600m - 2800m it increases to 89 (Table 3). The 2800m - 3000m range shows the greatest rate with an average of 235 pellets observed per day (Table 3). Like Pradhan, Saha, and Khan's (2001a) study, these data indicate that red panda are relatively more abundant in the 2800m - 3000m range (Table 2,3).

Direct observations. During 67 field days, from November 2002 to mid-March 2003, the remains of one red panda were found and 5 red pandas were sighted. The frequency of sightings coincided with the density of scat distribution with one sighting at both the 2400m - 2600m and 2600m - 2800m range, while 3 sightings were observed from 2800m - 3000m (Table 3). The first sighting took place at 2857m along the border, 100 meters south of the Hagetham trailhead (Figure 7). The red panda popped its head over a small knoll, ran into the Nepalese side of the ridge, and then scampered across the border road into Singhalila National Park of India. The second sighting occurred at approximately 2442m, 0.5 km below Gairibas on the Jamuna-Gairibas road. This time the author and his assistant were able to observe the panda for approximately one and a half hours. The panda intently watched every move of the author and his assistant until they began to measure a plot in the tree below. It was at this point that the panda keenly looked around for an escape route. Once it found a route, it deliberately stepped one paw in front of the other, looking at the author and his assistant, and walked from the branches of a *Lindera pulcherrima* into a *Rhododendron arboreum* and scampered away over a large boulder. The third sighting took place at 2685m, directly below Kaiyakatta 200m southwest of Kaiyakatta creek, and was brief like the first. The red panda jumped down from its resting spot on a twisted *Rhododendron grande* stump and sped into the mist. The final two sightings took place on the last three field days. To test the observed distribution, three days were spent searching for the red panda. Around Kaiyakatta, trees that had the greatest number of pellets were encircled. Using this method, red panda were found two of the three days. On each occassion the pandas were found in the mid-afternoon, curled up with their heads tucked in their paws. One hour of video was taken before the pandas fled into the forest. The first sighting was at 2850m, 800m above the Dobato-Kaiyakatta trail .8km northwest of Kaiyakatta. The second sighting took place 150m below the Dobato-Kaiyakatta trail approximately 0.75 km from Kaiyakatta. Also, red panda hair was encountered 2000m directly below Kaiyakatta on the edge of the

Kaiyakatta stream. According to the locals, an unleashed Tibetan mastiff from Kaiyakatta killed the red panda 4 months earlier.

Relative Population Size and Structure

Relative Population Size. It is difficult to estimate the relative red panda population size because the population is not confined to the Nepalese side of the ridge and crosses over into SNP, India. In the study area, red panda are using an area of approximately 5.5km^2 (Figure 11). Using Pradhan, Saha, and Khan's (2001a) density figure of one red panda per 1.67km^2, the relative population size would be estimated at three red panda. However, based on the aforementioned data on villager sightings, and direct and indirect observations, there are 4 red panda inhabiting the study area (1 red panda per 1.38 km^2). Four of the five red panda seen were different animals. Each was distinctly different in facial markings and body size. Two were larger and two were smaller in size but were found in totally different locations within the study area.

Unfortunately, this population is heavily predated upon. In the last year alone, unleashed dogs killed two red panda in the study area. One hundred meters below Kaiyakatta along the Kaiyakatta creek a local Tibetan mastiff killed one. Above Piple, a cowherder's dog killed the other (Figure 7). The Padma Naidu Himalayan Zoological Park and Singhalila National Park (PNHZP-SNP) active release program may offset these losses. In the last two years, around Gairibas, it returned two red panda to the wild.

Population Structure. In this study, both snowtracks and pellet size suggest the existence of a breeding population in the study area. Snow fell three times, January 1, 2003, January 30, 2003, and March 4, 2003. However, only on the second snow event, January 30, 2003, were two sets of snowtracks observed. The tracks were observed 20 meters east of the border on the ridge above the Hagetham trailhead (Figure 7). One set of tracks was conspicuously larger than other. Therefore, based on Yonzon's (1989) observations, it was assumed that these tracks, which led from Nepal into SNP, India, were those of a female and her cub. After each of the other two snowfalls, just one set of snowtracks were observed. These tracks were both located 0.4 km south of Gairibas on the Gairibas-Jaubari trail and once again led out of the Nepalese forest into SNP, India (Figure 7).

During January 2003, 158 pellets were encountered and measured (Appendix 3). According to Yonzon's measurements (1989), 123 pellets were cub and 35 pellets adult (Table 4).

Microhabitat Structure and Use

To determine microhabitat structure, 133 random and red panda sign plots were measured. Of the 59 plots measured at the 2,400m – 2,600m range, 22% were red panda sign and 78% were random. From 2,600m – 2,800m, 57% of the 51 plots measured were red panda sign while the remaining 43% were random. While the uppermost range, 2,800m – 3,000m, had 61% red panda sign and 39% random among its 23 plots (Table 5). An importance value index (IVI) for tree species plus a list of dominant shrubs were created from these plots to determine the dominant species for red panda sign and random plots, and all plots (Table 5, 6, 7; Figure 12, Appendix 4, 5). Only species with an IVI of 10 or greater are considered.

Importance Value. The diversity level and species composition differ between red panda sign and random plots. At the 2400m - 2600m range, which is bordered by Dobato, Piple, Hagetham, Nuntala, Teenkharke and Sisne (Figure 7), random plots are more diverse than red panda sign plots. Random plots had 10 tree and four shrub species, while red panda sign plots contained seven tree and two shrub species. The red panda sign tree species are all representative of medium to large trees while two of the random plot species, *Eurya acuminata* (34.93) and *Lyonia ovalifolia* (16.54), are characteristic of disturbance (Figure 12). Also, the shrubs represent this characteristic with *Viburnum erubescens*, an opportunist species, present only in the random plots (Table 6). This difference is due to the location of the red panda sign and random plots. Most of the random plots are directly adjacent or close to a village while the red panda sign plots are away from the villages. The 2600m - 2800m range, which has no villages bordering it, is the opposite, red panda sign plots are more diverse with 13 tree species and two shrub species, while random plots have eight tree and three shrub species. This range is the least disturbed and contains the largest pure *Lithocarpus pachyphylla* stands. The five differing dominant tree species, *Acuba himalaica* (21.80), *Symplocos ramosissima* (16.17), *Schefflera impresa* (13.27), *Acer sp.* (12.60), and *Symplocos theifolia* (11.46), are representative of undisturbed oak stands with a diversity of upper and lower canopy species present (Figure 12). The most important for the red panda, according to local villagers, is *Schefflera impressa*, because it is where they are most often seen. Again, in the highest altitudinal range, 2800m - 3000m, the red panda sign plots are more diverse with 11 tree and 4 shrub species while 8 tree and 3 shrub species dominate the random plots. Four villages, Gairibas, Kaiyakatta, Kalpokhari, and Jaubari border this range, which combined have a population of 133 inhabitants. The composition of both random and red panda sign plots indicate disturbance. The most dominant tree species for the panda sign plots with an IVI of 43.37 and second most dominant for random plots with and IVI of 39.17 is *V. erubescens*, an opportunist shrub or small tree usually found in overgrazed and disturbed areas (Figure 12). Another shrub characteristic of disturbed or overgrazed areas found in the panda sign plots is *Piptanthus nepalensis* (17.42) (Table 6). The IVI of all plots further support this with two of the most dominant tree species being opportunists, *S. ramosissima* (50.09), *V. erubescens* (41.49), and *Piptanthus nepalensis* as the most dominant shrub (Table 7).

Ringal Bamboo. *Malingo* (*Arundinaria maling*) and *ningalo* (*A. aristata*) are the two types of ringal bamboo found in the study area, of which *malingo* (88.8%) is most abundant. According to locals, red panda prefer the leaves of *ningalo*, but it is sparsely found (3.7%). The mean number of culms per plot was 23.32, the average percent cover was 40%, and average height was 2.92m (Table 8). Both species reach full maturity in three years, with *malingo* being the taller and larger in diameter of the two. In ten months, a *malingo* culm grows to about 2m in height and 3-5cm in diameter (Table 8). To create new shoots, the culm needs to be cut, otherwise the mature stem falls off without new shoots growing. If the culm is cut properly 4-6 new shoots will replace the cut culm.

Substrate Use. The four substrates used by red panda were tree, rock, ground, and logs and these differed by season. In the winter, trees, rocks and logs were used with trees (91.4%) being the most common followed by logs (5.7%) and rocks (2.9%) (Table 9). In the spring, all four were used with trees, once again, the most common at 66.2%. However, there was a much higher percentage of ground (16.9%) and rock (12.7%) used (Table 10).

Tree Use. Red panda scat was found on 16 tree species. From the most commonly used to the least commonly used they are: *Lithocarpus pachyphylla* (24%), *Schefflera impressa* (16%), *Magnolia campbellii* (15%), *Sorbus cuspidata* (10%), *Litsea sericera* (6%), *Lindera neesianna* (6%), *Betula utilis* (5%), *Rhododendron arboreum* (4%), *Hymenodictyon excelsum* (4%), *Rhododendron falconeri* (4%), *Rhododendron grande* (2%), *Ilex diprenya* (2%), *Saurauia griffithii* (2%), *Evodia fraxinifolia* (1%), *Vitex heterophylla* (1%) and *Lindera pulcherrima* (1%) (Table 10). At their respective altitudinal ranges, *Shefflera impressa* and *Sorbus cuspidata* are not the most dominant species, however, they have a high use by the red panda indicating a preference for these species. The other species use is proportional to their impotance value.

Presence or Absence

Thirteen habitat and disturbance variables--season, canopy cover, altitude, tree density, average DBH, shrub cover, bamboo height, density and cover, and livestock, human, and *malingo* disturbance--from 133 red panda sign and random plots were analyzed by binary logistic regression using SPSS version 10.0™ software.

The first regression model has an overall prediction percentage of 80.4% (n=102) (Table 11). In this model, the strongest predicting factor of presence or absence of red panda is altitude (*P*= .01) (Table 11). There is a greater likelihood that red panda will not be found between the 2,400m – 2,600m altitudinal zone (ALTITUDE 1). The other predicting factor is livestock disturbance level (*P* =.03). If there is no livestock disturbance (L.S.(1)) or 50% - 75% disturbance (L.S.(4)) then it is more likely to encounter red panda than if there is 25% - 50% or 75% -100% disturbance. However, these results are biased because the 2,400m altitudinal line intercept has only one red panda sign plot. Therefore, another regression was conducted dropping all of the 2,400m data and removing altitude from the model.

The second regression model, which contained all of the aforementioned variables except altitude, has an overall prediction percentage of 79.5% (n=78) (Table 12). In this model, two significant predicting factors were included, canopy cover (CANOPY_C) (*P* = .022) and livestock disturbance level (L.S.(1)(*P* = .05), which represents no livestock disturbance (Table 12). The livestock disturbance level variable (L.S.(1)) suggests that presence of red panda is dependent upon no livestock disturbance. The fact that canopy cover is significantly important demonstrates the red panda's need for protection from the elements and predators. The disappearance of the L.S.(4) variable, which represents 50% - 75% disturbance, indicates that this was important only at the 2,400m altitudinal transect. On the other hand, the continued presence of the L.S.(1) variable, representing no livestock disturbance, in both models suggests that red panda are sensitive to livestock disturbance and prefer undisturbed sites.

To further understand the influences on the presence or absence of red panda, all variables were categorized into 4 categories. This regression model is the most predictive at 86.1% (n = 79) (Table 13). Again canopy cover (CANOPY_C) (*P* = .011) and livestock (L.S.(1)) (*P*= .02) were the most influential, but a third, average DBH (AVG._DBH.), was also included (*P* = .04). Tree DBH is directly proportional to a trees height and related to canopy cover. Usually, the greater a trees DBH the greater its height and canopy cover. In this case, red panda are more likely to be present in areas of mature oak and mixed broadleaf forests where the dominant trees have a large DBH, and greater height and broader canopy cover.

Human Ecology of Jamuna and Mabu

Cultural Landscape

The angled slopes of the Ilam uplands are dotted with homes and goTH's[3] (pronounced "goat") that are permanent parts of this Nepalese mid-hill landscape. This section describes and defines these homes and their inhabitants, how these people survive in this harsh environment, and how these homes came to be.

Household. In this study the term household means the resources and structures used by one family to survive. This includes a barn for livestock, small field, usually 10 ropani or less (Table 14), house, and a kitchen (Figure 13). The two types of homes in the study area are a traditional mud, bamboo, stone, and wood structure with a bamboo

[3] Metz (1994) defined *goTH* as a temporary shelter used to house a cowherd and their livestock.

thatched roof and a more "modern" home made of two by four planks with a tin roof (Figure 14). According to the demographic survey, the majority of homes (59%) are traditional with bamboo roofs (Table 15). A traditional home has one story with two rooms, a kitchen and sleeping quarters, and is made of thatched bamboo walls covered in mud or thick stone and mud walls, a thatched bamboo roof, and has post beams made of medium sized trees (diameter >50cm) and roof beams, to hold down the bamboo thatch, made of small sized trees (diameter <35cm). A "modern" timber home is also one story with 3-5 rooms and is constructed with two by four planks and a tin roof. Most households, whether they have a traditional or modern home, have a separate structure for the kitchen. When a new home is built then the old home becomes the kitchen. However, if no new home is built then a kitchen, in the traditional style with bamboo-thatched walls covered in mud and a bamboo-thatched roof, is constructed. The last structure found at a household is a barn. It is also made of bamboo and trunks of small (15-25cm DBH) trees. It functions as a place to protect and hold livestock and its size depends on the amount of livestock held by each household; the greater the number of livestock the larger the barn. Every household has on average 10 *ropani* (20 ropani is equivalent to 1 ha) of land and plants potatoes, corn, carrots, radish, cauliflower, cabbage, cardamom, garden peas, and sometimes *kucho.* The only non-cash crops are corn and potatoes. homes, how these people survive in this harsh environment, and how these homes came to be.

Demographics. This section discusses the results of the demographic survey and land use questionnaire. In particular, it describes the similarities and differences between the north and south study area with regards to household and economic indicators. Specifically, the household variables discussed are number of households, number of inhabitants per household, religious group, average male and female age, and percentage of male and females. The economic variables discussed are percentage educated, percentage outside the village, average monthly expenses, income sources, food security, loan status, and 2003 income status.

To analyze the demographic and land use survey, the study area was divided geographically into north and south. The north had 37 households (32.7%), including Kalpokhari (10), Dobato (14), Piple (8), and Kaiyakatta (5), while the south had 76 households (67.3%), consisting of Sisne (12), Nuntala(7), Teenkharke(5), Gairibas(6), Hagetham (10), and Jaubari (36) (Figure 7,15).

The north is less populated with 141 inhabitants and an average of 3.81 inhabitants per household (Table 16). Piple has the highest average of inhabitants per household at 5.13, while Kalpokhari has the lowest average at 2.70. The south has almost thee times as many inhabitants (364) as the north and an average of almost one person more per household (4.79). Nuntala has the highest average number of inhabitants per household at 7.43, while Jaubari has the lowest average at 3.69 inhabitants per household (Table 16).

Kirat, Bhuddism, and Hinduism are the three religions followed in the study area. Each religion has a separate set of norms and values that influence followers environmental beliefs and land-use.

Limbu, Rai, and Sunwar ethnic groups follow the Kirat religion, which is a mixture of animism and Hinduism. Their religion is based on a body of myths and ritual focused toward the appeasement of ancestral dieties and spirits associated with nature, however they celebrate Hindu holidays (Daniggelis 1997). Hunting is a part of the Kirat origin myth and is passed on from father to son. Because of this, they are the only hunters found in the study area.

The Bhotia, Sherpa, Tibetan, Tamang, and Gurung ethnic groups are followers of Nyingmapa, the oldest sect of Tibetan Buddhism. In this form of Bhuddism, l*amas* (Buddhist priests) are the spiritual guides that help villagers walk the path toward enlightenment (Daniggelis 1997). In Daniggelis' study area (1997), *lamas* become practitioners to follow in the steps of their forefathers. In this study, becoming a *lama* or having a son become a *lama* was a symbol of status and a source of income. If a family could afford to send a son to Kathmandu or India it gained them respect among the local community. In the area, there are few economic opportunities outside of farming and *lamas* are paid for their services. Many *lamas* from Hagetham were called as far away as India to conduct ceremonies and rituals. As strict Bhuddists, Bhotias, Sherpas, Tibetans, and Gurungs do not kill any animal. Some of the elder practitioners also view the forest as an abode for dieties and spirits. The most interesting cultural change is the shift of faith for the Gurungs. Up until a few years ago Gurungs practiced a mix of Hinduism and Buddhism, but now they are solely Bhuddist.

Newar, Kaiya, and Brahmin ethnic groups worship the Hindu faith. They follow the same rituals and myths of Indian Hindus. In Jamuna and Mabu, animal skins are important to a conservative Hindu. The most important are deerskins, because pundits used them for prayer and meditation in the epic tales of the Mahabarat and Ramayana.

Buddhists dominate the study area, both north (80.3%) and south (70.3%), with Sherpa being the most prevelant ethnic group. Among the other religious groups, there is a significant difference in the number of Hindus and Kirats in the north and south study area ($P = .024$). Based on a chi-square test, the north has a greater than expected number of people who are Kirats (10), mostly from the Limbu ethnicity, and fewer than expected number of Hindus (1), while the south demonstrates the opposite with fewer than the expected number of Kirats (7) and more than the expected number of Hindu (8) (Table 17).

The gender composition follows a similar pattern. The percentage of males (53%) and females (43%) is roughly equivalent for the overall study area as for the north (54% males and 46% females) and south (53% males and 47% females), but the average male age differs. The north has a higher average male age (29.64) than the south (27.26). Overall, Dobato (41.82), a marginalized agropastoral village in the north, has the highest average male age (Table 16).

The economic indicators of percentage educated, percentage outside the village, average monthly expenses, income sources and food security are reflections of the settlement history. The other indicators, loan and 2003 income status, demonstrate recent changes in the local economy.

For purposes of this study, a person is considered 'educated' if they have gone to school up to grade four or higher. The north (42%) is less educated than the south (53%)

with a 9% difference (Table 18). The areas with the lowest percentage of educated inhabitants, for the north and south, are the interior villages of Piple (29%) and Hagetham (21%). Consequently, the locations with the highest percentage of educated inhabitants, for both the north and south, are the border towns (Table 18). In the north, Kalpokhari (44%) and Kaiyakatta (53%), and south, Gairibas (68%) and Jaubari (62%) have the highest percentage of educated villagers (Table 18).

One indicator of village wealth is to determine the number of inhabitants living outside of the village. In Jamuna and Mabu, 14% of all villagers are living outside of the area (Table 18). There are more villagers in the north (17%) than in the south (13%) that live outside of the village. Only the northern villages of Kalpokhari (44%) and Dobato (13%), and southern villages of Jaubari (22%), Gairibas (16%) and Hagetham (10%) have villagers living outside of them (Table 18). All of the villages but Hagetham are reflective of a larger economy created by the border road. In these rural communities the families have enough money to send their children to boarding schools in Darjeeling or Ilam, giving them access to future job opportunities. The border towns, Kalpokhari, Jaubari and Gairibas, have more diverse and larger economies and their children are sent to Darjeeling, while the children from Dobato are sent to Mabu or Ilam to study. In Hagetham, it is an indication of culture and faith; the boys are sent to study Buddhism as *lamas* in monasteries in India and Nepal.

There was little difference between study area monthly expenditures as a whole (2830) and those in the north (2815) and south (2844). However, villages with larger households, such as Piple (3625) and Teenkharke (4000), and more wealth, such as Jaubari (3459), tend to spend more monthly (Table 18).

Income sources, including those ranging from a tea stall to vegetable farming, were divided into six main categories: livestock, farming, labor, business, government jobs and foreign wages. Over the whole study area, households have anywhere from one to three different income sources. Northern households have less diverse and fewer income sources than the southern households. In the north, only four of the six categories are represented and households have one to two income sources. The primary income sources for these households are livestock (61.8%) followed by farming (20.6%), then business (14.7%), and lastly government jobs (2.9%) (Table 19). For these households, farming (47.4%) is the most used secondary income source (Table 20). Southern households use all six types of income sources and a household can have up to three income sources. In the south, once again, livestock, though not as important as the north, is the most used primary income source (38.8%), followed again by farming (22.4%), then labor (17.9%), business (16.4%) and government jobs (4.5%) (Table 19). Like the north, farming (42.5%) is most heavily relied upon for a secondary income source (Table 20). However, unlike the north, southern households have a third income source which include foreign wages (10%) (Table 21).

Farming is the second most important primary income source and the most important secondary income source in the area (Table 19, 20). However, this does not answer the question of food security. Do villagers produce enough to survive or do they have to take out a loan to buy food? The responses to the questions "How many months does your food last?" and "Do you have to take out a loan to eat?" indicate that most villagers are not producing enough to survive and have to take out loans.

Only 34% of all households produce more than a 5-month supply of food, and food produced by the southern villages lasts longer than in northern villages (Table 22). In the south, almost half (44.8%) of the households' food supply lasts for three to four months, with the observed number of households (30) being significantly larger than the expected number (25.6)(P = .031)(Table 23). Almost half (42.9%) of the northern households food supply lasts zero to two months with there being a significant difference in the observed (15) and expected (9.6) number of households (P = .031)(Table 23). Most households (70.5%), whether in the north or south, have to take out a loan to eat (Table 23).

The above-mentioned income sources did not increase household income in the last year. Most households (75.6%) had a decrease in income, with the south, particularly Jaubari, having a significantly greater number of households with a decrease (48) than expected (42.3) (P = .003) (Table 24). However, the north, specifically Kalpokhari and Kaiyakatta, had a significantly greater number of households with an increase (13) than expected (7.3) (P = .003) (Table 24).

Current study area demographics are dependent upon household decision-making, and reflective of settlement history and recent changes in economy. The north has fewer households and a smaller population than the south. Buddhists, with Sherpas as the most prevalent ethnic group, dominate the area. There are more males in the study area than females and males in the north are slightly older than males in the south. The early settlement and commerce of the border villages has affected the area in two ways, through education and income sources. It has created a more educated population and a culture of sending children outside of the village for education. In southern border villages, it has produced more income source options due to strong business ties to the Darjeeling economy. However, in recent years the economy has been changing. Instead of trade, livestock is the most important income source. Most villagers have to take out a loan to eat and, in 2003, they saw a decrease in their income, with the south and Jaubari, in particular, receiving a greater decrease than the north. By examining Jamuna and Mabu's settlement history, the intricate migration web can be weaved to explain current land use, ownership, and management in terms of their effect on red panda habitat.

Settlement History. Sir J.D. Hooker provided one of the first written descriptions of the Jamuna/Mabu study area. In 1848, he hiked from the Indian border at Tonglu through thick forest (along the southern border of the study area), and then into a less dense forest and camped in what he called Jummanoo (Jamuna) (Hooker 1855,177) (Figure 7). Today this trail is dotted with small villages and each village has a unique settlement history that dictates its culture, economy and land use.

The creation of Darjeeling, only 19 km to the west, is the most important factor in the development of the region. In the early 19th century, it attracted Nepalese to its many jobs, such as tea-picking, road and building construction, and portering for exploration. In the late 1940's, to secure the Nepalese-Indian border, the British began building a road. Before its construction, it took two or three days walking from Jamuna or Mabu to reach the closest market town, Manebhanjyang, which limited migration into the area.

Most of the area was used as spring and summer pastures for agropastoralists from Jamuna and Mabu. As one older Kalpokhari resident stated,

> I came to Darjeeling because I heard the streets were paved with money. It turned out that I had to build the roads with my bare hands for only one rupee a day.

The construction and completion of the road transformed the marginalized uplands into the region's economic center. What used to be a two to three day walk turned into a 3-4 jeep ride. Villagers, who used to trade their wares at weekly fairs, now had access to the Darjeeling market. Road workers and businessmen moved in and, where there were only cattle herding *goTHs* before, small trading villages were created. An interesting dichotomy emerged with all of the border villages (Kalpokhari, Kaiyakatta, Gairibas, and Jaubari) becoming trading villages, while the interior villages (Dobato, Piple, Hagetham, Sisne, Nuntala, and Teenkharke) remained marginalized.

<u>Border villages</u>. In 1951, Kalpokhari, Kaiyakatta, and Gairibas had no permanent structures. The only strucutres found in each place were *goTHs* that were used for spring and summer grazing by Maimajhuwha, Jamuna and Mabu agropastoralists. There were around 40-50 head of water buffalo, sheep, and goats per *goTH* and the thick jungle surrounding them provided the agropastorialists with an abundance of resources. A year later, the first structure of contemporary Jaubari, a seasonal *goTH*, was built next to a seep on a ridge overlooking the Jogmai river valley. By 1953, the border road was completed and British Range Rover jeeps began traveling to and from Manebhanjyang. It was around this year that Kaiyakatta was given its name. A lodge, located at this small pass next to a pond, was built and operated by a person of the Kaiya ethnic group. A Maimajhuwha villager saw the Kaiya's money and stabbed or *kat* him with their *khukhuri*

knife, thus originated the name Kaiyakatta. From 1956-1964, Kalpokhari was at its peak because of its proximity to Panchthar, the district to the north. Brahmin and Sherpa businessmen moved in and four new homes were built for a total of nine homes. Weekly, 100 to 150 *Panchthare*, villagers from Panchthar, came to sell their potatoes for 3 Nrp a màn (40 kg). The land surrounding the homes was cleared and plowed and it produced 100 màn of potatoes per hectare. It was around this time that Jaubari was created.

From 1963-64, a connector road from Jaubari to the border road was constructed. Over the next five-year period, because of its central location for 5 VDCs, Jaubari became the economic center of the northeastern Ilam uplands. During this time period, a small seep that was at the center of the Jaubari ridge was filled. Brahmin, Kaiya, Tibetan, and Bhotia businessmen, who built 20-25 homes, then cut the jungle around the seep. Jeeps transported goods to and from Manebhanjyang and the Indian Cooperation Mission (ICM) in partnership with HMG Ministry of Agriculture began a potato development project. At the same time the construction of the Ilam-Panchthar road to the west came to completion causing a decline in the *Panchthare* and forcing several businessmen to move away from Kalpokhari, leaving two Sherpa families as the sole residents (HMG 1969). The ICM-sponsored potato project lasted for nine years and greatly influenced trade in the area. In the early 1970's, a Nepalese customs checkpost was built in Kaiyakatta because of the increase in trade. In1976, the project came to an abrupt halt after reports of corruption. King Birendra flew in from Kathmandu to observe the status of the project, and soon thereafter the program was shut down. However, the project established a strong trading link between Jaubari and Manebhanjyang businessmen and few people left the village. For the next 17 years, little settlement occurred in Kaiyakatta, Gairibas, and Kalpokhari. Local Sherpa and Gurung villagers built seasonal huts in Kaiyakatta and Gairibas and moved in and out of Kalpokhari mostly using its upland pastures for summer pastures. It was during this time period that Jaubari grew to its peak of around 40 households. Gurung, Rai, Tamang, and Damai people migrated in creating the melting pot of Nepalese ethnic groups found today. Villagers would walk 8-10 hours to sell any and every good from medicinal plants to potatoes. In the late 1980's, Indian scientists began surveying the national forests adjacent to these villages for the possibility of creating a reserve.

In 1993, Singhalilha National Park was established, influencing the settlement of the region by providing permanent and seasonal employment and business opportunities. In Kalpokhari, Kaiyakatta, and Gairibas, forest guard posts were created and operated by locals with Indian citizenship. Also, park officials began promoting tourism to the area and private lodges were soon built in Kalpokhari and Jaubari while a government lodge was built on the Indian side of the ridge adjacent to Gairibas. Before the park's establishment local children, after being educated in Darjeeling, would leave the area because of a lack of work opportunities. The burgeoning tourism industry provided them with an opportunities to apply their education and skills in their home villages.

Park policies also influenced settlement. Herding was not allowed in the national park and the *goTH* owners had to either sell their herds or move to Nepal. It was because of this policy that two Bhotia herdsmen moved to Kalpokhari creating the Sherpa-Bhotia community found today. The most recent major change in settlement has occurred in the last seven years.

Before 1996, Jaubari was the closest roadhead for the five border VDCs in northeastern Ilam. Since 1996, four roads were completed connecting these VDCs to Indian and Nepalese Markets to the west and southwest, and causing a decline in Jaubari's ecomonic power and population. For the average villager of these VDCs, the roads cut market travel time from 4-5 hours to 1-2 hours. In response to this change six buisnessmen and their families migrated from Jaubari. One migrated to each of the following places: Birtamod, Ilam, Darjeeling, and Kathmandu, while two migrated to Sikkim.

Interior Villages. Unlike the border area, the settlement of the interior villages was driven by space considerations. Before 1950, Limbu, Rai, and Brahmin villagers used Hagetham, Piple, and Dobato as seasonal grazing lands. After 1950, as the population increased, fertile lowland resources became scarce and seasonal grazing lands were gradually turned into permanent settlements.

In 1950, settlement of this area began when an indentured Tamang *goTH* herder built the first permament home in Hagetham. Three years later, a Jamuna Limbu family turned their *goTH* in Piple into a permanent home. Following Tamang and Limbu customs, each family divided up their land among their sons. Over the next 40 years, in each village five sons built homes on the ancestral land, creating the village structure found today. Dobato was settled much later. According to a 67-year-old Rai villager, his family has used Dobato as seasonal grazing land for four generations. However, he stated that it was not until the 1980's that people began to use the area on a year-round basis. Specifically, in the last ten years, six homes were built because of the proximity to ample fuelwood and fodder, which has become scarce in other parts of the village.

Today around Dobato and Piple this process is still ongoing. Over the past 50 years, the ridge between these two villages, called *Surke Danda,* was used as seasonal grazing land. In 1960 there were two *goTHs,* which used several *ropani* of land each, on the ridgline (HMG 1960). Since then one permanent home and four *goTHs* were added. And in the last few years, four families began living in them year round. However, it is unlikely that this ridge will turn into a Hagetham, Dobato or Piple, where the homes were built on private land, because two of these structures are located on national forest land (HMG 1960).

Land Ownership and Management

Land Ownership. Today, land ownership is a product of history and perceptions. The Lepcha, the original inhabitants of eastern Nepal, first ruled the study area and were overthrown by the Limbu (Schwerzel, Tunistra, and Vaidya 2000). This area was called the *Pallokirat* or far kirat and both Rais and Limbus owned the land (Daniggelis 1997). In the late 1700's, when the Shah regime took over the throne, the Rai and Limbu were allowed to maintain their traditional forest management system called the *kipat*. Usually, in this communal system of land tenure, villagers share all forest resources (Daniggelis 1997). However, in the case of Jamuna and Mabu, the *kipats* became privately owned parcels. These parcels, owned by Limbu and Sunwar families, were then sold to Tamang, Sherpa, Rai, Gurung and Brahmin families, many of whom came to work on the border road. Until the 1971 government survey, the most influential event on current ownership, the selling and reselling of *kipats,* occurred. For the 1971 survey, many uneducated landowners, being afraid of taxes, did not declare all of their land, while educated landowners declared more land than they actually owned. For example, one Kalpokhari man, who owned 50 ropani of what was once the local Thebe *kipat*, only declared 5 ropani, and another Kalpokhari landowner, who owned 50 ropani of land, declared 200. This created the current dichotomy of private and public land ownership.

According to the 1971 survey maps, all of the land in the study area is government owned land, except for small parcels attached to village homes, two two-*ropani* pieces of land on the ridge between Dobato and Piple, a 10-*ropani* lot on the Piple ridge, another 10-*ropani* parcel on the border directly south of Kalpokhari, and a 40 *ropani* lot to the northeast of Jaubari (HMG: Ilam Land Survey 1960) (Figure 16).

Land Management. Legally, the two managed forest types in the study area are 'national' and 'community'. Three fourths of the study area is national forest and one fourth of it is community forest (Figure 16). However, in Jamuna and Mabu, the observed and legal managers differ. Three entities manage the land, two of which are *kipats* that operate without government consent. A Limbu family from Piple and Sherpa family from Kalpokhari manage these *kipats*, covering the northern half of the study area, while the Hagetham Community Forest Committee (H.C.F.C.), a local committee working under the auspices of the Ilam District Forest Office (D.F.O.), manages the southern half (Figure 17).

The Piple Limbu and Kalpokhari Sherpa *kipats* are managed with different styles and levels of power. For 50 years, the Piple Limbu has managed their land by force. If someone is on the Piple *kipat* without consent, they will roll rocks at him or her from uphill and tell him or her to leave the land. However, most land users know the *kipat* rules and before they step foot in the Piple *kipat* pay a land use fee of 500 Nrp, a bottle of *rakshi*, local rice liquor, and a 40 kg bag of potatoes or10 liters of *churpi,* a form of hardened cream which sells at high prices in the Nepalese and Indian market, or cow milk. During the course of the study, six *goTH*s paid these user fees to the Piple Limbu family. According to the Piple Limbu, forest products are taken from their *kipat* on a need only basis. However, all but three of the homes constructed in Dobato this past year were made from wood poached from the Piple *kipat*. To legally gain control of the Piple *kipat*, forest users from Mabu applied to the D.F.O. for the creation of a community forest. This would end the rule of the Piple *kipat* by the Piple Limbu and transfer power into the hands of local forest-users.

Locals still refer to the area along the border from Kalpokhari to Kaiyakatta as the Sherpa *kipat*, however, over the last four years the Kalpokhari Sherpa have been losing their control of it. Until this time, the father of the family strictly enforced and collected a 500 Nrp a year user fee. After his death, with the sons spread throughout the area, Kalpokhari *kipat* land users began paying land use fees only on government registered land. The southern half of the study area has a completely different management history and scheme.

Until 1959, when the *Jamuna Panchayati Ban* was created, two families managed the southern half of the study area as *kipats*. The Jamuna Bhattrai family managed the eastern ridge above Hagetham and the Teenkharke Mukya family managed the northern half of the Jaubari ridge. These families strictly managed each area and little poaching or illegal activity occurred. In 1959, the beginning of the *Panchayat* era, this area was combined and called the *Jamuna Panchayati Ban* or Jamuna Panchayat Forest. In 1973, the name was changed to the Jamuna Community Forest (J.C.F.). The period from 1973 to 1991 was the most influential on forest management. During this period, Hom Khar Bhattrai ruled the Jamuna Community Forest Committee (J.C.F.C.). His brother, the *Pradhan Panchayat* (equivalent of village president) appointed him president of the J.C.F.C. He approved all forest usage and did not allow timber harvesting, and influenced the Ilam D.F.O. to conduct a Swiss Development forest conservation program in Jamuna. From 1980-1989, this program focused on reforestation with non-native pine and *Cryptomeria japonica*, and had 5 men working as forest and nursery guardians. The forest was surveyed and 600 ha were declared under J.C.F.C management, and the rest of the area was designated as National Forest. However, Hom Khar did not trust the villagers to protect the National Forest and managed the whole area. From this point forward all of the Jamuna uplands were perceived as part of the J.C.F.

In 1991, democracy began, and the J.C.F.'s name changed to the Jamuna Community Conservation Forest which two years later changed again to the area's current name, the

Hagetham Community Forest (H.C.F.). With democracy, land users elected the forest committees but the perception that all of the Jamuna uplands were committee managed did not change. The elected committees decided and enforced land use rules based on a framework given to them by the D.F.O. In 1999, 276 households elected the current Hagetham Community Forest Committee (H.C.F.C.).

The current H.C.F.C. has a difficult time managing the Jamuna uplands because of its size and a lack of funding. Committee members are volunteers and spend a majority of their time attending to household duties. They do not monitor forest activity to enforce rules, such as no hunting, which is freely practiced. Therefore, endangered species like the red panda have no protection. However, in its three years of existence, the committee stopped grazing around Hagetham and removed three *goTHs*. Also, it changed regulations on firewood and timber harvesting. Firewood and timber were harvested year-round. Now, firewood can only be harvested two months a year and timber can only be harvested one month a year. The H.C.F.C. budget is made up of funds from the D.F.O. and firewood and timber harvesting fees. In 2002-2003 the budget was 58,500 Nrp, consisting of 13,000 Nrp from the D.F.O. and 42,500 Nrp in timber and firewood user fees. For 2003-2004, their budget will consist of only the D.F.O.'s 10,500 Nrp because they forbid firewood and timber collection. The 2003 H.C.F.C. operational plan called for the establishment of two nurseries and the planting of 10,000 trees. They hoped to raise the lost timber and firewood fees through the sale of cardamom and medicinal plants. Mature lower mixed broadleaf forest was cut for the planting of the cardamom and medicinal plants. In 2004, the H.C.F. management area will change because the Ilam D.F.O. planned to conduct a forest survey and officially hand over the forest to the H.C.F.C. This would create more involvement from the D.F.O and limit the power of the H.C.F.C. over the Jamuna uplands because all of the area outside of the H.C.F. will officially be National Forest.

For the last two years, D.F.O. involvement in forest management has been limited. Forestry officers have sporadically visited the Mabu or Jamuna National Forests because of Maoist activity to the north along the Panchthar and Ilam district border. During 2002-2003, the author knew of only one visit by the head District Forest Officer because he was being transferred to Pokhara. According to local villagers, D.F.O. officals have done little to enforce National Forest rules, such as no building of structures or roads, timber or firewood cutting, or grazing, in the Mabu and Jamuna uplands. All the roads under construction in the research area were not surveyed before being built (Figure 7,18). The lack of D.F.O. involvement in forest management and a lack of education about the H.C.F and National forest rules, has created negative perceptions among villagers of both the Ilam D.F.O and H.C.F.C.

A majority of land users do not understand that grazing is banned or the length of time which firewood and timber *purji* (collection) are open. According to 70.3% of southern households and 79.4% of northern households grazing is not banned (Table 25). Most households (62.6%) believe that firewood can be collected for three or more months a year, when it is open for two months (Table 26). A majority of northern households (51.7%) believe that timber *purji* is open each year, when it is never open. And several southern households (33.3%) think that timber *purji* is open three or more months a year, when it is actually open for only one month (Table 27). This apparent lack of communication and a lack of observed benefits create negative perceptions of the D.F.O. and H.C.F.C. One Jaubari resident stated that the H.C.F.C took money for reforestation from them every year for the last three years but they have not seen one tree planted. However, 64.6% of southern households had seen reforestation in the last year, while almost no reforestation happened in the northern National Forests (91.4%) (Table 28). A Hagetham resident believes that the H.C.F.C is running a lucrative timber business and laundering the funds. While a Piple resident says that neither the H.C.F.C. nor the D.F.O. enforce forest rules and regulations. These perceptions play a part in current land use and the potential success of future forest development projects.

Land Use

This section will explain land uses and how they are detrimental to red panda habitat. Land use decisions are driven by land ownership and management but most importantly the economy. In the study area, livestock and farming are the most important income sources and sketch map interviews and participant observation identified six detrimental land uses that are associated with these income sources. They are, from most to least damaging to red panda habitat: grazing, *malingo* cutting, firewood cutting, timber cutting, fodder collection, and hunting. These land uses are found throughout the study area, but have intensive use areas. The first subsection, land use locales, describes where the six land uses occur and the second subsection, detrimental land uses, is and in depth analysis of each land use.

Land Use Locales

Sketch Maps. Four sketch map interviews were conducted, two in the north, Dobato and Kalpokhari, and two in the south, Hagetham and Jaubari. Land uses differed between the interior and border villages, with the interior villages using the study area more diversely. In the H.C.F.C. management area, which includes Piple, Kaiyakatta, Gairibas, Jaubari, Teenkharke, Nuntala, Sisne, and Hagetham (Figure 7), members of the Hagetham Community Forest Committee (H.C.F.C) identified six primary land uses: grazing, firewood, timber, *malingo*, and fodder cutting, and hunting. According to H.C.F.C. members, firewood cutting occurs around Hagetham, Jaubari, Nuntala, and Teehkharke, timber is cut to the east above Hagetham and to the northeast of Teenkharke, grazing occurs above and around Piple and below Jaubari, m*alingo* cutting takes place around Kaiyakatta, Gairibas, and Jaubari, fodder is cut and collected around Hagetham, Teenkharke, and Nuntala, and hunting occurs throughout the whole management area (Figure 19). When asked which land use is most damaging to their forest, H.C.F.C. members unanimously agreed that it is grazing. The Dobato map differed by one land use, hunting. According to male community members, grazing, fodder, firewood, timber, and *malingo* cutting are their primary land uses. Grazing occurs up to 2 km to the east and south, fodder is collected around the village, firewood is cut along the Kaiyakatta trial and in the jungle within a kilometer to the south, timber cutting takes place below the village and to the southeast, and *malingo* cutting occurs 2 km to the southeast above the Kaiyakatta trail (Figure 20). Here the most detrimental land use is timber cutting.

The border villagers distinguished three primary land uses: grazing, firewood, and fodder cutting. According to Kalpokhari residents, all three land uses occur 2 km to the west along the Dobato trail and 3 km to the south along the border road (Figure 21). Jaubari residents stated that they have two primary land uses: grazing and firewood cutting. These activities take place below the village and to the northeast along the border (Figure 22). In all villages grazing is considered to be the most detrimental land use.

Observed land users were from villages outside of the study area. In each sketch map interview, villagers were asked if other people used the study area and if so where they lived. Mabu villagers from wards two, five and eight,, and Maimajhuwa villagers, from ward number nine use the northern part of the study area, while villagers from Jamuna, wards number one, three, four, and seven, use the southern part of the study area for *malingo*, fodder, hunting, and timber.

Observations. Slope, proximity to villages, and, in the case of timber, forest type, dictate land use location. The two most widespread land uses are grazing and *malingo* cutting. Grazing occurs from the northern study area border of Dobato and Kalpokhari 4 km south toward Piple and 2 km in from the eastern Indian border around Kaiyakatta and Garibas and extends 3 km to the north of the southern border villages of Jaubari and Nuntala (Figure 23, 24). Two seasonal *GoTHs* are located above Piple on the Piple ridge. In all the other areas grazing occurs year round. *Malingo* cutting has a similar pattern but is not as widespread as grazing. It takes place from the northern border south and east above the Kaiyakatta-Dobato trail along the Indian border around Kaiyakatta, 2 km in from the border between Kaiyakatta and Gairibas, 1.5 km below and to the northwest of the Gairibas-Jaubari trail, and 1.5 km to the north and west of southern border (Figure 23). Firewood, fodder, and timber collection are more localized, with firewood and fodder collection occurring together and within close proximity of villages while timber is being cut in small old growth pockets. Firewood and fodder are gathered within close proximity to all the villages but firewood is more intensively cut in the border villages and around Hagetham, while fodder is cut more intensively in Kaiyakatta, Dobato, Kalpokhari, and Jaubari (Figure 23, 24, 25). Timber is logged directly south and east of Dobato, along the Dobato-Kaiyakatta trail, along the Piple-Kaiyakatta trail, and north of Jaubari (Figure 25). Hunting, based on signs of bear, deer, and wild boar traps, takes place in a 3 km radius around Gairibas, Jaubari, Kaiyakatta and shots were fired near Dobato (Figure 25).

Detrimental Land Uses

Grazing. The study area has been grazed for at least 156 years. At Tongloo, just to the southeast of Jaubari, Hooker's entourage bought meat for their evening meal from a "Guroong" (Gurung) shepard, whose flock grazed the area (1855). Today, local perceptions differ concerning the role of grazing in jungle destruction. Some locals do not see cattle but *chauri,* a yak/cow crossbreed, as the main problem. A common statement is, "Cows don't climb trees." A former *chauri* herder, described this perception,

> *Chauri goTHs* have to move from place to place, use more firewood, and the *chauri* destroy the jungle. I know. I lived in a *goTH* for 20 years. Once they

> created Singhalila National Park I sold all my animals to India, moved here and began my business. We need to get rid of all the *goTHs*.

Undoubtedly, in Jamuna and Mabu livestock is the most important income source. Livestock includes goat, cows and their calves, oxen, *chauri* and their calves, horses, and water buffalo, which are sold for meat and their milk used to make cheese and *churpi*, a form of dried cream. The meat, *churpi* and cheese are produced for foreign markets, mostly Darjeeling. *Chauri* meat and beef are sold in Darjeeling while all other animals are raised for household consumption. Cattle and *chauri* salesman travel across the border and purchase *chauri* and cattle at low prices and sell them in India reaping the benefits of the exchange rate. Twenty-five years ago, Tibetans introduced *chauri* and *churpi* to the area and since, *churpi* has become one of the main income sources. It is easily produced in dairies, homes, and *goTHs* from cow and *chauri* milk and sells for 160 Nrp/kg in Darjeeling from where it is shipped to Switzerland and Germany.

Stall-fed and free-range cattle and *chauri* supply the two *churpi* production methods, dairy, and household, resulting in differing red panda habitat degradation. Households produce the majority of study area *churpi* and only in Hagetham, Sisne, and Nuntala are cattle stall-fed (Figure 7). Overall, stall-fed cattle are less degrading to the jungle. Fodder is cut selectively, and regeneration is allowed to occur. However, *malingo*, 80% of the red panda diet (Pradhan, Saha, and Khan 2001b), is the most favored fodder cut. Also, many times children are sent to cut fodder without learning proper pruning techniques, resulting in a loss of regeneration. Throughout the rest of the study area, milk is provided from free-range cattle or *chauri* that graze the uplands of the northern study area and southern border villages, where red panda reside. According to northern villagers, they need nine to ten head of cattle to turn a profit. The actual numbers of livestock head per household and mean number of livestock head per household reflect this statement. In the north, 67.6% of the households have ten or more livestock head per household, while in the south 76.3% of the households have 9 livestock head or less ($P = .000$) (Table 29). Also, the mean number of livestock head per household demonstrates this difference, with the north (13.11) having a significantly greater mean than the south (7.75) ($P = .045$) (Table 30). These free-range livestock cause the greatest degradation to red panda habitat.

Free-range livestock do not allow for forest regeneration and slowly, if allowed to graze year-round, turn the once lush Eastern Himalaya Broadleaf forest into shrubland and grassland (Figure 26). The shrubland and grassland around Kalpokhari, Dobato, Kaiyakatta, and Jaubari, are examples of this pattern, which, according to local elders, 50 years ago was thick jungle. *Malingo* regeneration is most important to the red panda and free-range livestock eat *malingo* bamboo shoots causing its decline. Red panda also eat other herbs and use trees as shelter from predators and for breeding (Yonzon 1989). A lack of regeneration limits the growth of these other potential food, shelter, and breeding sources. The majority of free-range livestock in the study area are *lekhali* cattle, a local breed, however, in Kalpokhari, Kaiyakatta, and Jaubari several homes own *chauri* and for four months annually a *chauri goTH* is stationed on the ridge above Piple. Locals say the *chauri* are more damaging than *lekhali* cattle because they are more agile and can get to hard to reach places, eat more, and travel further everyday. On several occasions, along the Piple ridgeline, the author observed *chauri* standing on steep rocks eating malingo and other overhanging vegetation. On the other hand, *lekhali* cattle overgraze a smaller area because of their lack of agility and the roughness of the terrain.

Malingo Cutting. In the Ilam uplands, *malingo* is essential to human and red panda life. A local woman aptly stated its importance as "No malingo, no work." Without it a household would not function. It is used as fodder, roofing, fencing, walls, and baskets, for bedding, to support crops, as combs, kitchen utensils, and baby cribs (Figure 27,28). Red panda would die without it. It is 100% of their diet for seven months of the year and 47% during the other five months (Pradhan, Saha, and Khan 2001b). Today, there is less available for humans and red panda because of shoot over-consumption, over-harvesting, and the recent blooming of Prang, another domesticated small bamboo that is planted around village homes.

In the monsoon, *malingo* and *ningalo* shoots are not only eaten by red panda but by villagers and livestock. During this time period, when shoots are available, livestock are not banned from the forest and, according to local villagers, eat a majority of the shoots. The leftover shoots are plucked up by villagers to make masala or are sold in local markets. According to Pradhan, Sahan and Khan (2001b), household consumption by border villagers was 10.96kg/family. In the last 10 years shoot, and therefore bamboo, availability has declined. The culms usually are procured for household-use, however, poor village men will cut it for 1Nrp each. A household uses an average of 1038 culms per year with the north (1111) using more culms than the south (965) (Table 18). Four villages, Kaiyakatta (1700) and Dobato (1404) in the north, and Hagetham (1700) and Teenkharke (1020) in the south, use the greatest amount of *malingo* yearly (Table 18).

The residents of these villages live a more traditional agropastoral lifestyle, in which livestock is their primary income source. These households have a lower education level and tend to use *malingo* for most of their household needs.

The introduction of the tin roof has decreased *malingo* usage for roofing. Twenty years ago, all village homes had *malingo* thatched roofs, today 59.3% of homes have *malingo* thatched roofs (Table 15). It takes 1500 culms to build a *malingo* roof, which usually lasts for three years, while a tin roof lasts 7 years and costs 15,000 Nrp.

Yearly household *malingo* usage (117,294 culms) is greater than the current number of culms available in the study area (30,667 – 57,319 culms) (Table 31). Therefore, the culms cut in Nepal are thinner in diameter, usually immature, and used for fodder, bedding and basket making, while for all other uses Jamuna and Mabu villagers must cut *malingo* from Singhalila National Park, India. Another cause of *malingo* decline is the flowering of Prang, which happens every 12 years. Two years ago, this domesticated medium size bamboo flowered causing all of its culms to die, and villagers from Maimahjuwha, Jamuna and Mabu, who used to cut it for all their household needs, now have to rely on *malingo*. Kalpokhari and Dobato villagers said the number of *Malinge* or *malingo* cutters, has doubled or even tripled during this time period. According to elderly villagers *malingo* last bloomed in 1950. When it does again and all of it dies, it will be a difficult three years for humans and for the survival of the red panda.

<u>Firewood.</u> The amount of firewood consumed yearly makes it the third most detrimental land use to red panda habitat. Besides *malingo*, trees are of second most

importance to the red panda. They are used for nesting, sleeping, shelter, and feeding (Pradhan, Saha, and Khan 2001a; Yonzon 1989; Johnson, Schaller and Hu 1988). However, firewood is required for most household energy needs. It is used for cooking, heat, and drying. It is needed to cook human and livestock meals, for making *rakshi*, homemade rice or wheat liquor, and *chang*, homemade rice or millet wine, in the preparation of *churpi*, and for keeping clothing and bodies warm and dry during the winter and monsoon.

Locals had much to say about firewood and its use. The northern and southern households collect their firewood from different forests. The majority of northern households (77.6%) cut their firewood in a National Forest while the majority of southern households (74.3%) use the Hagetham Community Forest (Table 32). Villagers said that *Lekh* or upper elevation homes and g*oTHs* use more firewood than other areas. *Lekh* homes use it because of the climate. In the winter it is cold and in the summer it is damp, therefore these households need to keep a fire going all day. A g*oTH*, also located at upper elevations, needs even more firewood than a home to cook the milk for *churpi* and meal for the livestock. Northern households, which are all *Lekh*, have a significantly greater percentage (44%) than southern households (24%) that say there has been an increase in fuelwood usage (P = .042) (Table 33). Overall, it takes longer in time and distance to get firewood than it did 5 years ago, but less in time and distance than it took 10 years ago (Table 34, 35). Villagers from Dobato, Kalpokhari, Gairibas, and Hagetham stated that they only cut naturally downed trees. Observations showed the opposite in each location, where live trees were felled for firewood (Figure 29). This could be the result of over-consumption or an inadequate supply of naturally downed trees.

Average household firewood consumption is 21 loads a month (Table 18). On an annual basis, therefore, households consume 1017 medium size (30-50 DBH) or 452-565 large size (50-80 DBH) trees (Table 36). Consumption varies depending on elevation and economy. The north (24) uses more firewood than the south (19) with all the *Lekh* villages, except Jaubari, consuming more than the lower elevation villages (Table 18). In Jaubari, a *pill* of firewood, which is has 30 loads, costs the same amount of money and lasts the same amount of time as a cylinder of natural gas. Therefore, of the 12 homes with gas, 10 are in Jaubari, lowering its average household firewood consumption (Table 37).

Timber. Recent economic and cultural changes have modified timber use. In the past, swidden agricultural practices used old growth trees as fences. In a five-ropani area, the four largest trees were cut, and their trunks became fence sides and the branches became firewood. In Piple and Dobato, these old fences are reminders of another time when potatoes were the most important income source. Today, trees are cut for new home, trail, and road construction.

In 2002-2003, 28.2% of households built a new home or g*oTH*. The north had a significantly greater percentage (44%) of new homes or *GoTHs* built than the south (Table 38). One of the new homeowners stated that it took seven medium-sized (30-50cm DBH) trees and the overall cost to build a two-story structure, including the tin roof, carpenters, and loggers, was around 100,000 Nrp. The cost of a traditional home is considerably lower because it requires little skilled labor and most materials come from the local forest. The extraction of bamboo and construction of thatch is done by the homeowner. However, the construction of a wood home is a sign of wealth and many villagers strive to build one. In the past two years eleven wood homes were built. In 2002, four homes, three lodges in Kalpokhari and one home in Hagetham, were construced. In 2003, seven homes, one each in Kalpokhari, Hagehtam, Teenkharke, and Kaiyakatta and three in Dobato, were constructed (Figure 30). Much of the wood for these homes was cut during the expansion of the area's roads and trails.

Seven years ago, to support and enhance the local economy, a one-meter wide horse trail between Dobato and Kaiyakatta (Dobato-Kaiyakatta) was cleared. Since then, changes in wealth have increased the number of jeeps. Two jeep roads from Dobato to Kalpokhari (Dobato-Kalpokhari) and Jaubari to Teenkharke (Jaubari-Teenkharke) are being constructed (Figure 7). In this construction, many felled old growth tress were either sold to Darjeeling or used locally in home construction. Along the Dobato-Kaiyakatta trail alone, the author counted 30 felled old growth trees. Despite the increase in new home construction, the majority of locals (83.9%) believe there has been a decrease in local timber usage (Table 39) and have not planted timber trees on their land (Table 40). Therefore, the future timber supply will continue to come from the surrounding national and community forests that house the red panda.

Fodder. Since the creation of the Hagetham Community Forest, fodder usage has increased and availability decreased. Unlike firewood, most fodder is cut from the National Forest (67.8%), and a greater percentage of northern households (89.5%) use the

National Forest for their fodder needs than southern households (57.1%) (Table 41). Most villagers cut two loads of fodder a day, one in the morning and another in the evening. For larger animals, jungle grazing does not provide sufficient calories and their diet is supplemented with cornmeal. According to local farmers, green leaves have the most nutrients and provide livestock with minerals not found in the cornmeal. Overall, 46 types of trees and understory plants are used for fodder. During the monsoon, weeds and understory plant species provide the bulk of fodder. In the dry season, *malingo* bamboo is the most abundant and easiest to cut fodder source. However, if *malingo* is not available near the home, tree branches are cut. A preferred tree fodder source is *Balu Chinde (Shefflera impresa)*, the second most used tree by the red panda (Table 10). In some cases, improper lopping disables leaf regeneration decreasing the availability of fodder. This occurred around Kaiyakatta 30-40 *Shefflera impresa* were lopped to the trunk (Figure 31).

Usage differs between the north and south, with southern households using more fodder and having less available. There are several factors that indicate fodder usage: the average number of daily fodder loads, percentage of homes with fodder trees, and percentage of homes that have planted fodder trees. Availability is indicated by the percentage of households with enough fodder and the percentage of households that perceive an increase or decrease in availability. The average number of daily fodder loads is significantly greater for southern (2.94) than northern (2.15) households (Table 42). Fifty-two percent of southern households need 3+ loads daily and 54.3% of northern households need only 1-2 loads daily (Table 43). Only 55.5% of all households have fodder trees on their land. Therefore, 44.5% of the study area relies on the forest for 100% of their fodder needs (Table 44). A significantly greater percentage of northern (84.8%) than southern (50%) households perceive that they have enough fodder available ($P = .001$) (Table 45). However, 82.8% of all households perceive that fodder availability has decreased (Table 46).

Hunting. According to Hagetham Community Forest Committee members, and Dobato and Kalpokhari villagers hunting occurs throughout the whole study area. Most hunters are Rai or Limbu men, who are taught when they are 12-14 years old. A 65 year-old Rai man from Dobato stated that Rai men usually hunt in celebration of their tribe's attachment to nature. Twenty years ago, hunting was a lucrative profession and hunters sold anything they could kill. Foreigners bought birds for 5 Nrp and, in India, red panda fetched a price of 1,800 Nrp, which at that time was enough to feed a family for five months. To catch red panda, a line of 10 hunters would hike the forest on the sides of streams. When they saw a red panda, they would chase it up a tree, throw a bamboo lasso around its neck, yank it down from the tree, shove a piece of wood in its mouth to stop it from biting, and throw it into a sack. A middleman from the village of Rimbik, Darjeeling would buy the animals and send them through Calcutta to zoos around the world. According to Bahaguna et al.(1998), in the 1960's alone, 300 red panda were trapped and traded from the Singhalila range.

Today, hunting of the red panda has been minimized by the creation of Singhalila National Park, which increased awareness about its endangered status. However, *munal* (Crimson Horned Pheasant; *Tragopogon satyr*), *mirga* (Barking deer; *Muntiacus* *muntjac*), *kalo bhalu (*Himalayan Black Bear; *Selenarctos thibetanus*), *bandel* (Wild boar; *Sus scrofa*), and Thar (Himalayan Wild Goat; *Hemitragus jemlahicus*) are still hunted. Cattle and *chauri* herders, commonly called goTHwalla, tell the hunters the location of the prey and usually enjoy the spoils if a hunt is successful. Several of them have red panda fur on the inside of their wool coats. Three bear, four deer, and eight wild pig traps and 8-10 *Tragopogon satyr* kill sites were observed during the course of the study.

As mentioned in the red panda ecology section, the greatest threat to the red panda is unleashed household dogs. Forty-six of the 113 households have one or more dogs for a total of 57 dogs in the study area (Table 47). The majority of these dogs are unleashed. However, only two of the owners saw their dogs kill a red panda. Locals say that *goTHwalla* dogs are the greatest threat because these dogs are trained to hunt.

Conservation Efforts

During the Panchayat era attempts to create a National Park of the Jamuna/Mabu area failed. Recently, most work in the area has been focused on economic development and not biodiversity conservation. Two Ilam non-governmental organizations, Ilam Cultural Center (ICC) and Namsaling Community Development Center (NCDC), have conducted projects in Jamuna and Mabu. The eco-regional plan focusing on the PIS corridor has created an increase in the amount of money available for biodiversity conservation projects and several are planned for the future.

Past Development. Ilam Cultural Center is the smaller of the two and its expertise is social mobilization and rapid rural assessment (RRA). Namsaling Community Development Center, which just expanded into four districts, focuses on microhydro, school building, and community forestry projects.

Ilam Cultural Center has a stronger presence in Jamuna, where it completed a drinking water project in Sisne, and conducted a RRA and cultural program in Jaubari. In Jaubari, as a result of the RRA, it installed solar electrical systems in five homes and created a local community organization, called the Buddha Club. It plans to use the Buddha Club as a springboard to conduct future projects. In Mabu, it installed solar electricity in 2 homes in Kalpokhari and just began a clean water and sanitation project.

In 1998, NCDC conducted village Environmental Plans for both Jamuna and Mabu, and only if the VDC chairman asked them for help did they follow up on the plan. Mabu's VDC chairman asked NCDC to conduct projects in forestry, microhydro, and fogwater collection. In 2003, 500 homes were electrified, 3 nurseries were established and the Mabutham Community Forest reforested. In Kalpokhari, the fogwater project collapsed because of a land dispute.

Future Biodiversity Conservation Projects. In the next three years, ICC, NCDC, and the international non-profit organization, International Center for Integrated Mountain Development (ICIMOD), will conduct biodiversity conservation related projects in Jamuna and Mabu. International Center for Integrated Mountain Development, which specializes in research and capacity building in the Himalaya region, received a three-year grant focusing on capacity building in the eastern Himalaya.

It is specifically focusing on the Panchthar-Ilam-Singhalila corridor. In the spring of 2004, it will conduct a capacity building workshop with ICC and NCDC to create an Ilam-wide strategic biodiversity plan.

Last year, NCDC and ICC applied for a three-year UN biodiversity grant. With the grant, they plan to utilize the Buddha Club for forest conservation and management. The plan includes medicinal plant and organic kitchen garden training, hybrid livestock training, an aggressive reforestation program, and the utilization of gas for cooking.

IV. DISCUSSION

Overview

This thesis answers questions about red panda ecology, the conservation status of the red panda, and the cultural ecology of the Ilam uplands. In Jamuna and Mabu, the red panda is critically endangered and in dire need of protection through stringent conservation measures. In 2002-2003, because red panda prefer the upper mixed broadleaf forest adjacent to the border villages of Kalpokhari, Kaiyakatta, Gairibas, and Jaubari and the interior village Dobato, unleashed dogs killed two red panda. Large portions of this forest are disturbed from overgrazing, fodder collection, *malingo*, timber, and firewood cutting, causing the fragmentation of the red panda population on habitat islands between the villages. Projects, such as the PNHZP-SNP active release program, and the Ilam uplands strategic biodiversity plan, can ensure the survival of the red panda in this region through local participation and ownership.

Conclusions

Red Panda Ecology

The results from the ecological census demonstrate that four red panda use a 5.5 km^2 area of montane oak and mixed Eastern Himalayan Broadleaf forests distributed between 2600m - 3000m. Within this area its most abundant food source is *malingo* (*A. maling*). Like Pradhan, Shah, and Khan's study in Singhalila National Park, India (2001), direct and indirect observations indicate that red panda are relatively denser in the 2800m - 3000m range. However, during the past year, local dogs killed two red panda. Even with a breeding population present, because of low fecundity and predation threats, such as unleashed local dogs, yellow-throated martens (*Martes flavigula*), clouded leopards (*Neofelis nebulosa*), and leopards (*Panthera pardus*), there is a high probability of extinction.

Results from substrate usage contradict those found by Pradhan, Saha, and Khan (2001a). According to the Singhalia National Park study, red panda used rocks and ground more frequently as scat sites during the winter breeding months (Pradhan, Saha, and Khan 2001a). In this study, red panda used rocks and ground as scat sites during the end of the breeding season in late spring. The analysis of red panda sign plots and tree usage indicate that red panda prefer more diverse and mature forest with greater canopy cover and little livestock disturbance. However, observations and survey results demonstrate that even though red panda may prefer areas with little livestock disturbance there is little of this area available to them. In the 2800m – 3000m altitudinal range, the red panda's preferred range, only small areas of extremely steep terrain are not disturbed. At this altitude zone, the most dominant tree species, *S. ramosissima* and *V. erubescens*, and one of the dominant shrub species, *P. nepalensis*, are characteristic of disturbance. Two of the red panda's top four preferred tree species are also found within this altitude zone. However, these species have low or no importance value. *Balu chinde* (*Schefflera impresa)* its second, and *Tenga* (*Sorbus cuspidata*), its fourth most preferred species, are medium sized tree species associated with stream banks where their limbs extend out perpendicular to the steep slopes. *Malingo* usually juts up along the lower limbs providing red panda with food and its large flat limb joints provide them a perfect place for sleeping. From 2800m –3000m, these species were found only in red panda sign plots. These species may be absent because of overuse. *Sorbus cuspidata* is a favorite source of firewood and *Schefflera impresa* is used for firewood and fodder. Around Kaiyakatta locals cut 30-40 *Schefflera impresa* for fodder and firewood. Fifty years ago, the creation of the Nepal-India border road initiated the intense forest usage in this area.

Human Ecology

Jamuna and Mabu's settlement history influenced current study area economics and demographics. After 1953, when construction of the Nepal-India border road completed, and over the next 30 years, the Jamuna and Mabu border area became the economic center of eastern Nepal. Permanent settlements were built to facilitate new trade opportunities increasing population and local resource usage. The largest settlements created, Kalpokhari and Jaubari, were the most destructive to red panda habitat. Both villages, located at 2800m, intensely used forest between 2800m - 3000m, the preferred range of the red panda. Slowly over the last forty years, Kaiyakatta, Gairibas, Dobato, Piple, Hagetham, and Teenkharkhe transformed from seasonal grazing areas to permanent settlements. Therefore, around these villages, red panda habitat suffered less degradation. However, in the last 10 years, the creation of Singhalila National Park and construction of roads linking Kalpokhari to Mabu, Jaubari to Jamuna, and Teenkharke to Jaubari, have created more intense pressure on the remaining pockets of red panda habitat. Around Kaiyakatta and Gairibas the population doubled and many *goTHs*, which were located in India, moved to Nepal. Today, the upland economy is changing because of tourism and the creation of new roads, increasing the pressure on forest resources.

The Jamuna/Mabu economy was based on trade with Darjeeling because the border road was northeast Ilam's only link to Darjeeling. However, in the past three years roads linking Maimajhuwa, Mabu, and Jamuna to Ilam changed the flow of trade. The area's three main exports, garden peas, *churpi*, and cardamom, are still sold in Jaubari and Kalpokhari, where they fetch the highest price, but daily staples like rice and tea are bought at stores located in each village. Therefore, this change in trade has not affected the areas main income sources, livestock and farming. However, in Kalpokhari, Kaiyakatta, and Gairibas, tourism is changing the economy from agropastoral to service based. In the last three years, locals constructed six lodges to supply housing for visitors of SNP. These three income sources influence household and community land use decision-making.

Approximately 200 households use the study area to sustain themselves. This study focused on 113 households adjacent to the study area. These households have six land use types that affect the quality and quantity of red panda habitat available; grazing, *malingo* cutting, timber cutting, fodder collection, and hunting. From observations and interviews, land use locations depend on the activity. Daily activities such as fodder and firewood collection are performed within close proximity to villages. *Malingo* and timber cutting are specifically located where there are high quality, thick stems for *malingo* and straight trees for timber. While grazing and hunting occur throughout the entire area.

According to local interviews and observations, the most damaging land use to red panda habitat is grazing. Around the border villages of Dobato and Piple grazing is more intense because there is a greater average number of livestock head per household and the livestock are free range. Also, for four months a year, a *chauri goTH* is stationed on the ridge above Piple. This *goTH* contributes to greater disturbance because only small pockets of forest along steep slopes are out of reach to *chauri,* a yak/cow crossbreed. Around the villages, unmanaged grazing has destroyed potential forest regeneration. Fifteen years ago, Dobato villagers cut *malingo* within 150 m of the village. Today, they have to walk 1 km to cut it. Also, the once diverse montane oak forest is now comprised of two species, c*handan (Daphniphyllum himalayense)* and a*ngeru (Lyonia ovalifolia)*, rhododendron species that are poisonous to livestock (Appendix 6). Around Piple and

Kaiyakatta, the only saplings *Daphniphyllum himalayense* and *Lyonia ovalifolia* saplings are found. Red pandas do not frequent the areas where cattle graze because of the presence of local dogs, creating more limitations on red panda feeding sites.

Malingo cutting is another way feeding sites are becoming less available. The combination of *malingo* usage for fodder, construction, and other household uses is creating over-consumption. The presence of *Malingo* cutter paths everywhere and open understory floor is evidence of this over-consumption. However, the maturation of *Prang*, a domesticated medium-sized bamboo, and the increase in tin roof usage will decrease usage in upcoming years. Because of the importance of this resource to both red panda and people, efforts must be made to manage it. Otherwise, the current red panda population will not be supported.

Besides foraging, red panda spend half of their lives in trees sleeping plus female red panda use them for nesting locations. Unfortunately, trees are also integral to the functioning of Ilam households and their economy. Currently, 89% of households use firewood for all their energy needs. Local firewood usage rules state that only dead trees can be cut, but the demand for these trees exceeds the supply. Therefore, households must cut live trees to survive. Also, timber usage is increasing because of new construction methods. Most new homes are made of all wood when they used to be made of *malingo* and mud. In the past 2 years alone, 11 new homes were constructed. In 50 years, free range grazing, firewood consumption, and timber usange around all border villages has created large patches of grassland and scrubland, decreasing the amount of habitat available to the red panda.

Also, during the dry season, villagers prefer evergreen trees, the type of tree most used by red panda, for fodder (Pradhan 2001a). Since the creation of the Hagetham Community Forest in 1993, fodder usage has increased but availability decreased because of new regulations forbidding free-range grazing. This is mostly due to improper lopping of tree limbs, which decreases the availability of shelter for the red panda and increases the possibility of predation. Unleashed cow or *chauri* herder dogs, the greatest predatory threat to the red panda, roam the forest hunting. In 2002-2003 alone, they killed two red panda. High predation combined with the above-mentioned land uses threatens the small, vulnerable red panda population with extinction. Only through stricter management of the area can the red panda population's viability be ensured. This may be difficult to accomplish based on the complicated matrix of private, public, and traditional *kipat* land tenure and management in the study area.

According to the 1971 land-survey, most of the study area is government owned. Yet, the northern half of the study area is managed by two traditional *kipats,* the Piple Limbu and Kalpokhari Sherpa. In the last few years, locals are refusing to pay the *kipat* tax, asking to see a government sealed deed before they pay. This is leaving a management void that allows grazing and timber and firewood collection to go unchecked. In the south, the Hagetham Community Forest Committee has extended its 200 ha management area from Piple to Jaubari. Its volunteer members lack the proper training and financial resources to manage the area. Illegal grazing, firewood and timber collection, and hunting are widespread. The creation of a strategic biodiversity management plan for the area is the only measure that will ensure the future viability of the red panda population. In 2004, local and international NGO's hope to create one for the Ilam uplands. Local participation and ownership of this plan will be the key to red panda survival.

Recommendations

Half of this study focused on answering important questions about red panda population, distribution, and microhabitat use in eastern Nepal. However, because of the study's broad scope, details of red panda microhabitat usage were left unanswered. The area that is most useful to land managers and other conservation projects in Nepal is preferred habitat. More information about preferred red panda habitat is important to creating priority conservation areas. Future research can focus on the specifics of red panda microhabitat preferences. Do they prefer stream sites? If so, what is the preferred distance from a stream? Besides bamboo cover what other features are important to red panda? Further research could answer questions about tree and substrate usage. Do the red panda prefer old-growth trees? If so, are there preferred species? Do these preferred trees have specific characteristics, like height of the lowest branch, for instance? Of the 5 red pandas sighted only one was found above 8 meters in a tree. Do red panda use the upper limbs of a tree or was it just a case of being unable to climb the trees? Substrate usage is also important to understanding red panda behaviour. Why do red panda use different substrates at different times of the year? Is it for mating purposes or for the rearing of young? The discrepancy in *malingo* taxonomy is another important detail that needs to be answered. According to Manosh Acharya, Director of the Lloyd Botanical Garden, Darjeeling, *malingo* is *Arundinaria maling* (pers. com. 2003). However, in the *Dictionary of Nepalese Plants*, malingo is listed as *Thamnocalamus spathiflorus* (Shrestha 1998). This may be due to differences in local naming. In central Nepal, around Kathmandu, *malingo* may be *Thamnocalamus spathiflorus* while in eastern Nepal *malingo* is *Arundinaria maling*. Further study of this question can determine if these forms of *malingo* are the same or separate species. Thus providing more information to Nepalese land and conservation managers for the creation of management plans in *malingo* extraction.

Ultimately, the future of the Jamuna/Mabu red panda population depends on the local people. A more acute awareness of local perceptions and understanding of land uses are necessary for future conservation efforts. For Jamuna and Mabu, answers to questions about local environmental perceptions such as: "Do you think the red panda is important? Do you think the forests should be conserved? How important is the forest to your life? Are there any stories about the forest in this area? Are there any sacred places in the forest?" can help in creating the strategic biodiversity plan. This study determined that grazing, firewood, fodder, timber, and *malingo* extraction are the most detrimental to red panda habitat. A closer examination of these land uses can help prioritize management schemes.

Final Conclusions

This study examines the importance of economics in natural resource conservation. It gives a glimpse of a larger issue that faces eastern Nepal and many places in the "developing" world -- economic pressure drives resource usage. Once infrastructure is developed trade routes are created and, if left unmanaged, resources are extracted at an unsustainable rate causing degradation. In this case, the red panda is critically endangered because of unsustainable resource extraction. Unmanaged grazing, *malingo*, fuelwood, and fodder extraction limit available red panda habitat. This overexploitation of the local forest creates an open forest floor exposing the red panda to predation. Last year alone local dogs killed two red panda. An aggressive conservation plan that creates local stewardship and includes local management is the only hope for the red panda.

ILLUSTRATIONS

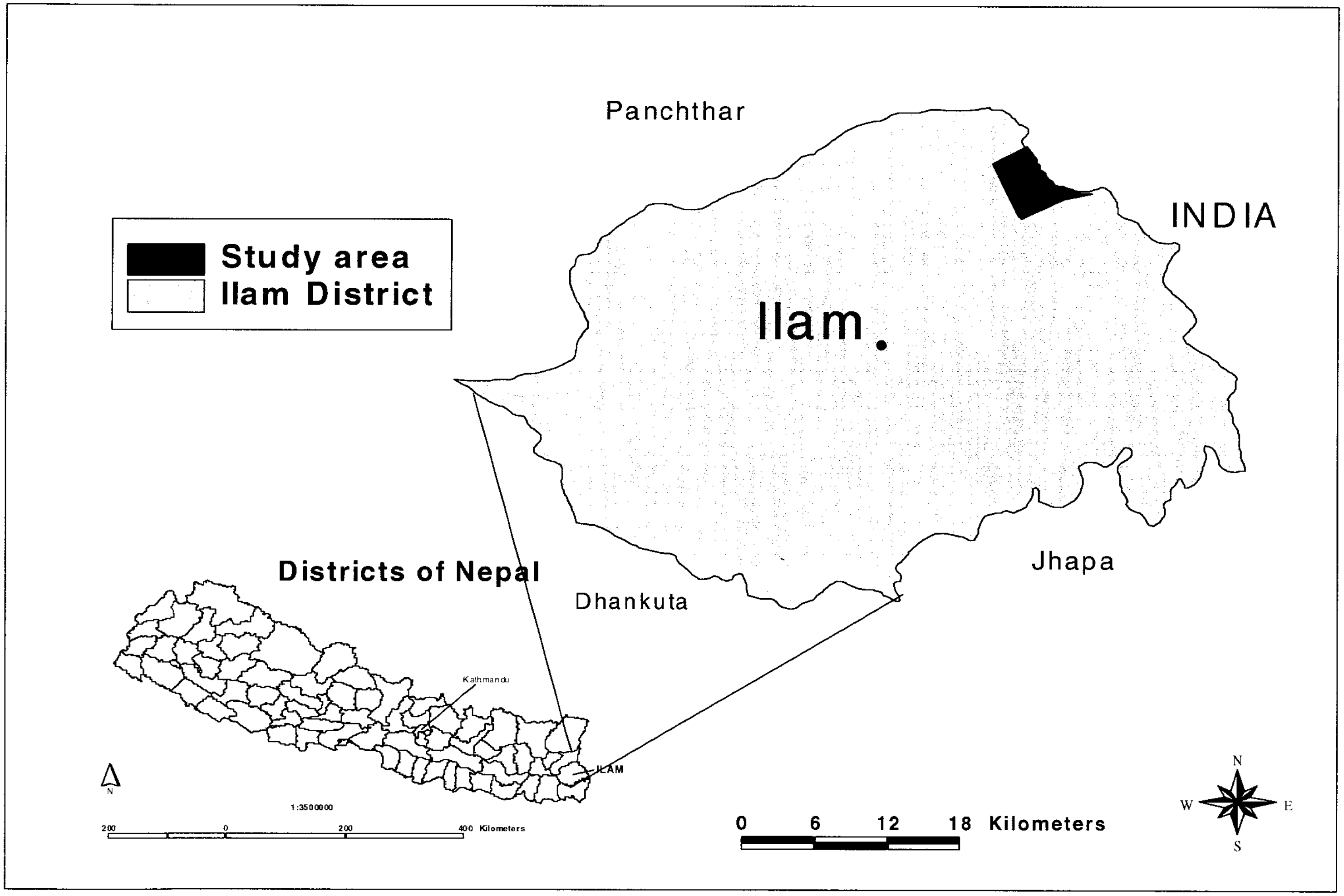

Figure 1. Study Area Location. The location of the study area in Ilam District, Koshi Zone, eastern Nepal.

Figure 2. The Last Red Panda (*Ailurus fulgens fulgens*). The last red panda seen by the author and his assistant. This shot was taken moments before it scampered off into the bamboo thickets of the Eastern Himalayan broadleaf forest.

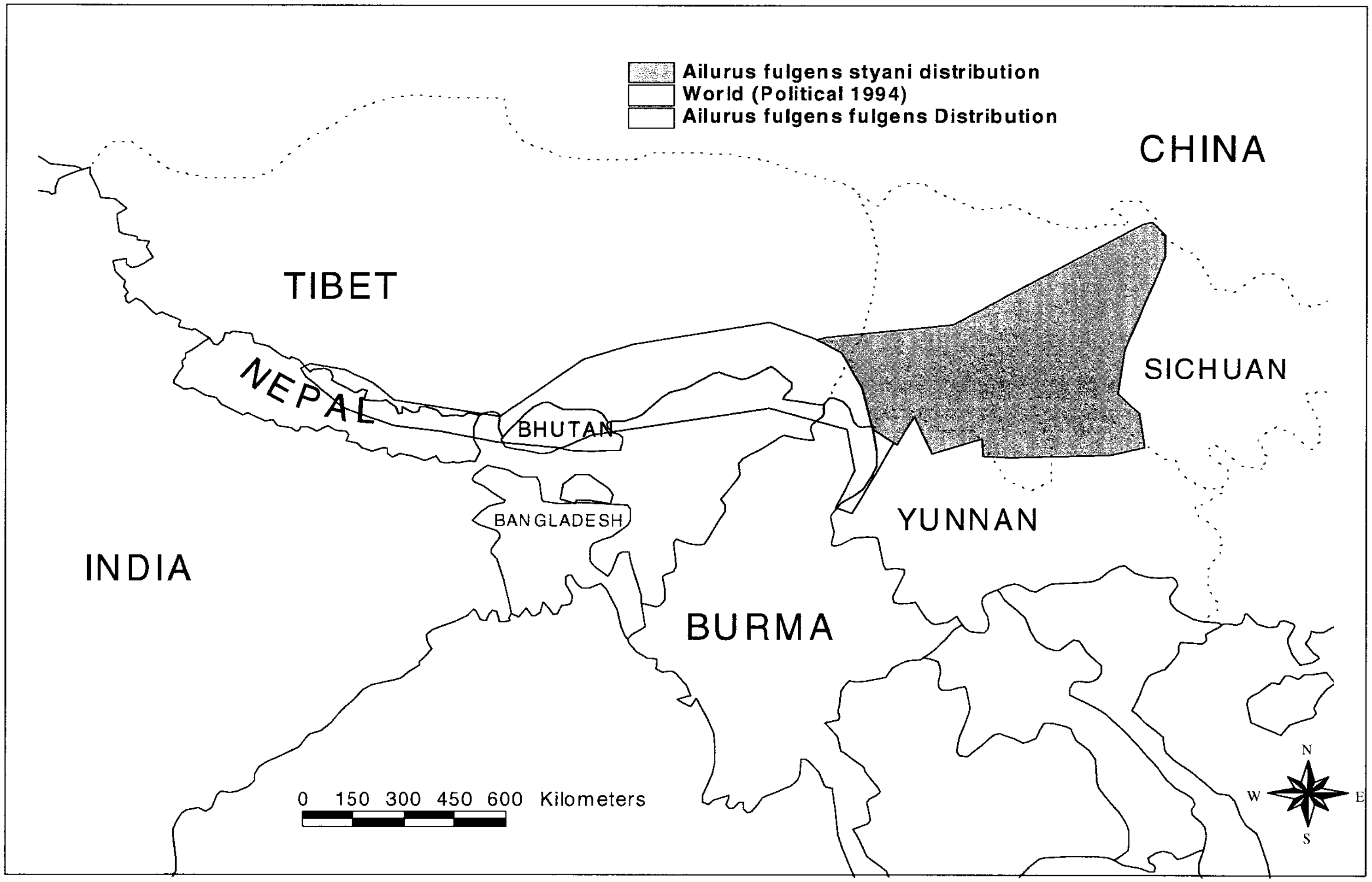

Figure 3. Global Distribution of the Red Panda. The countries are from east to west Nepal, India, Bhutan, Burma, and China. After Choudhury 2001,p. 251, and Wei et al. 1999, p. 287.

Figure 4. Eastern Himalayan Broadleaf Forest. This is a photo of Nima Pinju Sherpa on the Dobato-Kaiyakatta trail, which runs through the heart of red panda habitat; Eastern Himalayan Broadleaf forest. The red in front of Nima is moss growing on a tree stump. This moss, commonly found on most trees in the Eastern Himalayan Broadleaf forest, influenced the vibrant auburn color in the pelt of the red panda. Three years ago this trail was widened to allow for horse travel.

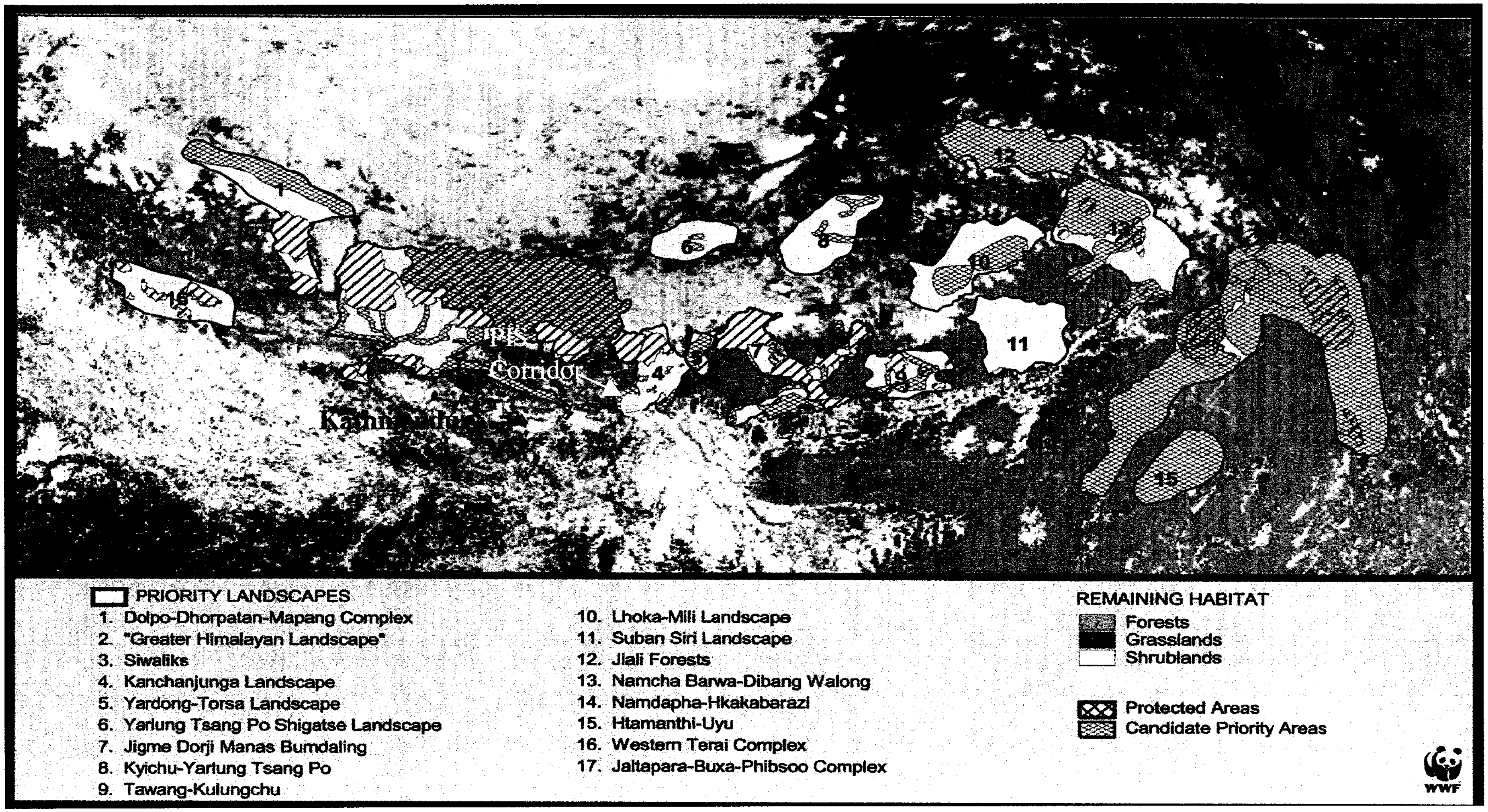

Figure 5. <u>Location of the Pancthar –Ilam-Singhalila (PIS) Corridor in the Kanchenjunga Mountain Complex.</u> The Kanchenjunga Mountian Complex, number four,and the PIS Corridor in relation to the Eastern Himalaya bioregion. Adapted from Wikramanayake et al. 2001, p 26.

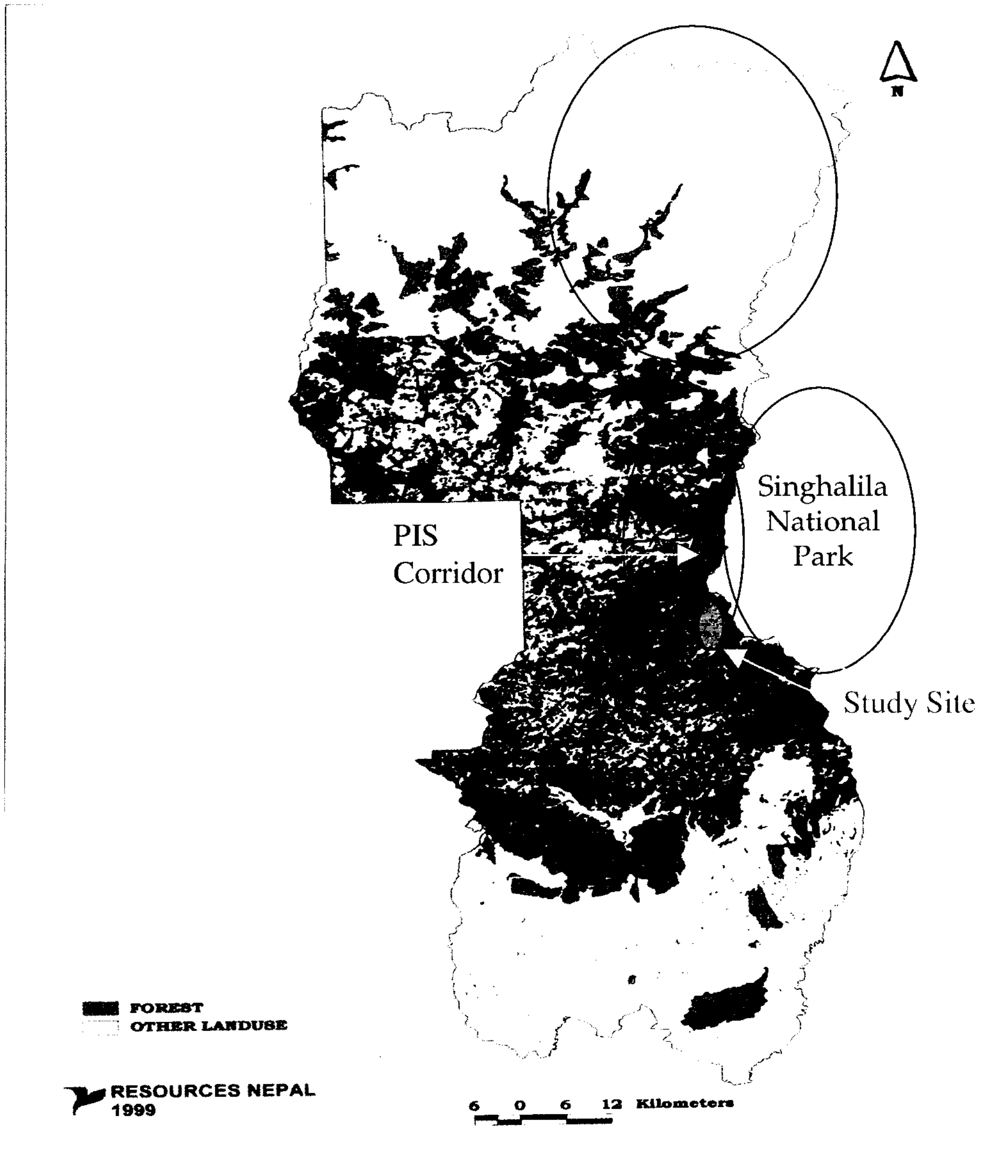

Figure 6. The Location of the Study Site in the PIS corridor. It connects the Kanchenjunga Conservation Area, Nepal and Singhalilha National Park, India. Adapted from Yonzon 2000, p. 21.

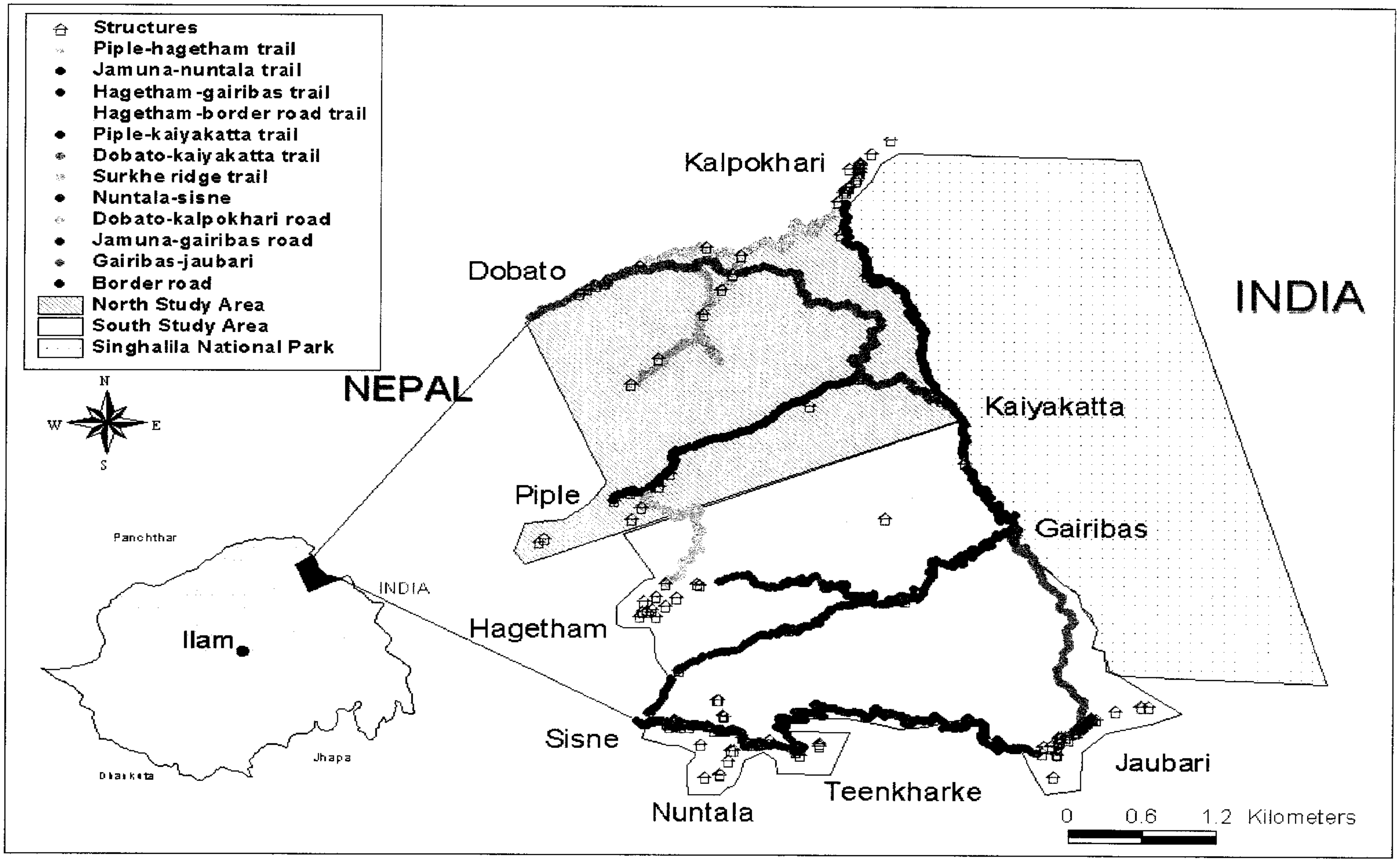

Figure 7. Map of the Study Area. The north and south study areas, which are used in the demographic analysis and land use questionnaire, are distinguished by the shaded areas.

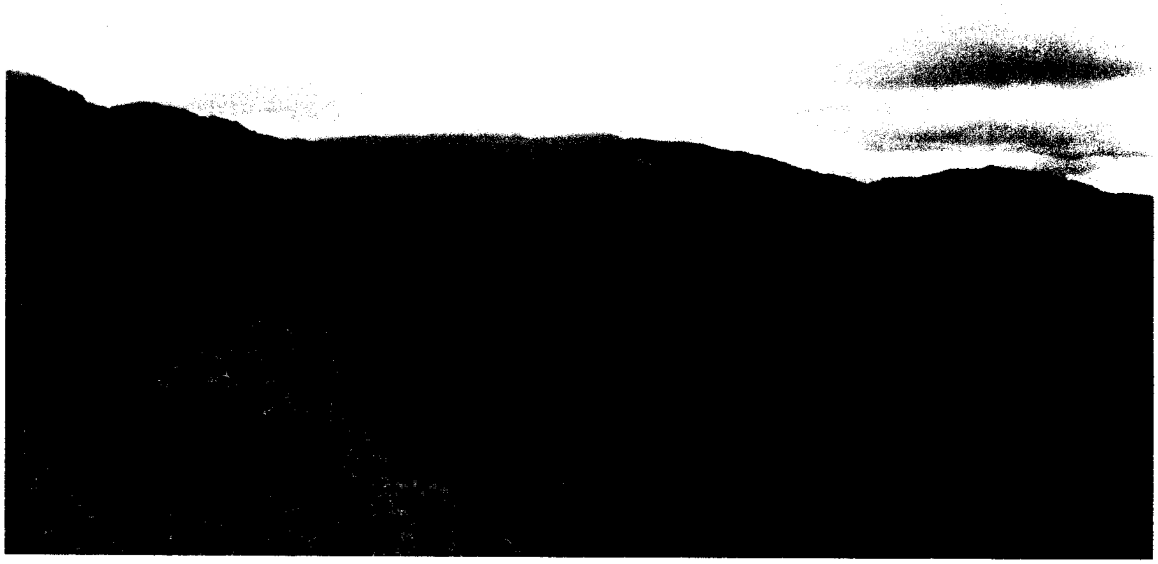

Figure 8. Landscape of the Jamuna/Mabu Study Area. This photograph, taken from Dobato looking south toward Jaubari, which is in the clouds, shows the entire study area and the largest contiguous *Lithocarpus* stands in Eastern Nepal.

Figure 9. The First Sign of the Red Panda. A red panda pawprint in cow manure, observed 100m to the northeast of the middle of theGairibas-Jaubari trail.

Figure 10. Red Panda Scat. The most commonly observed indirect sign of red panda presence.

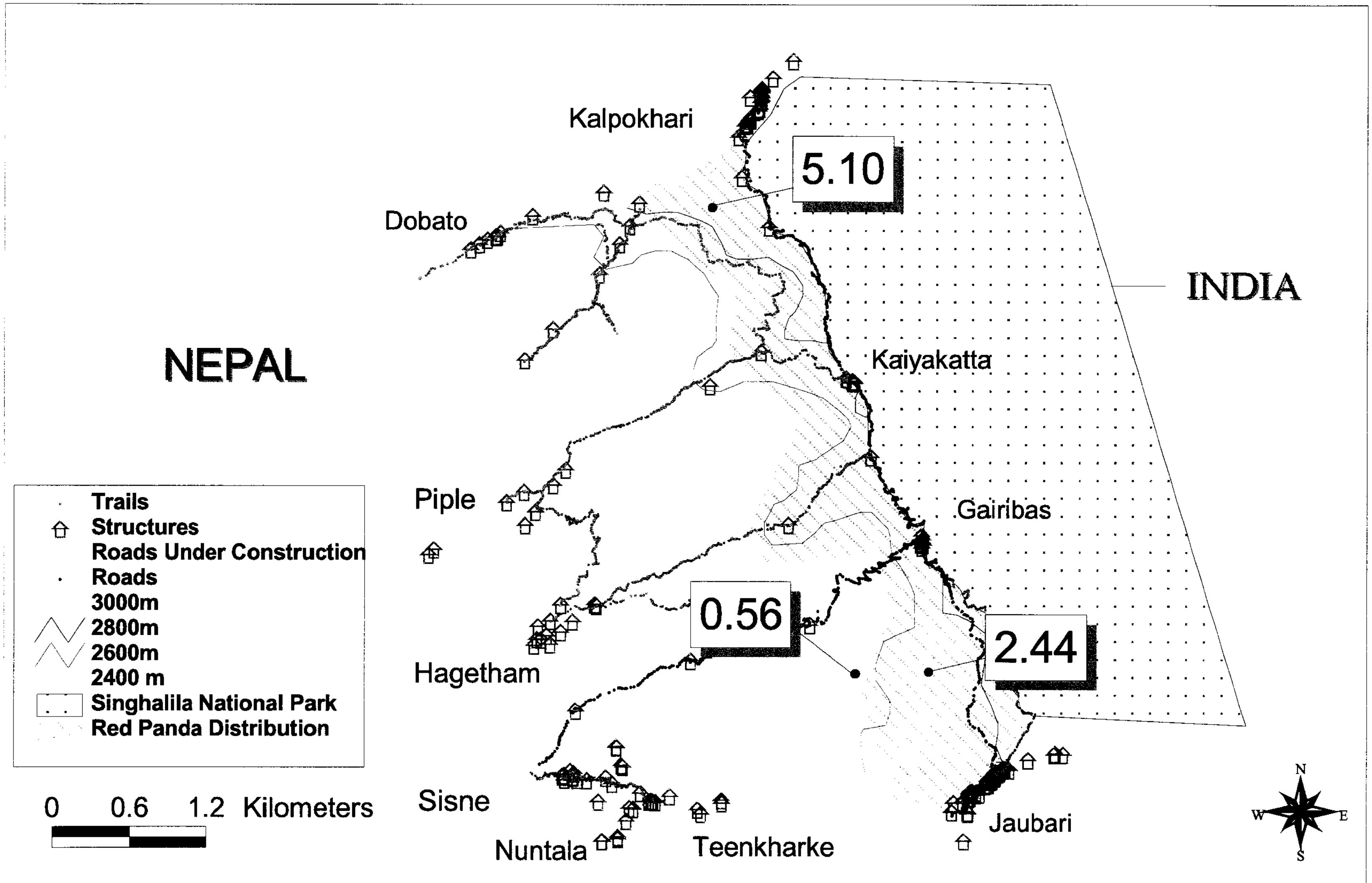

Figure 11. Map of red panda distribution in the research area. The numbers represent the frequency of red panda sign encountered per kilometer at each altitudinal zone.

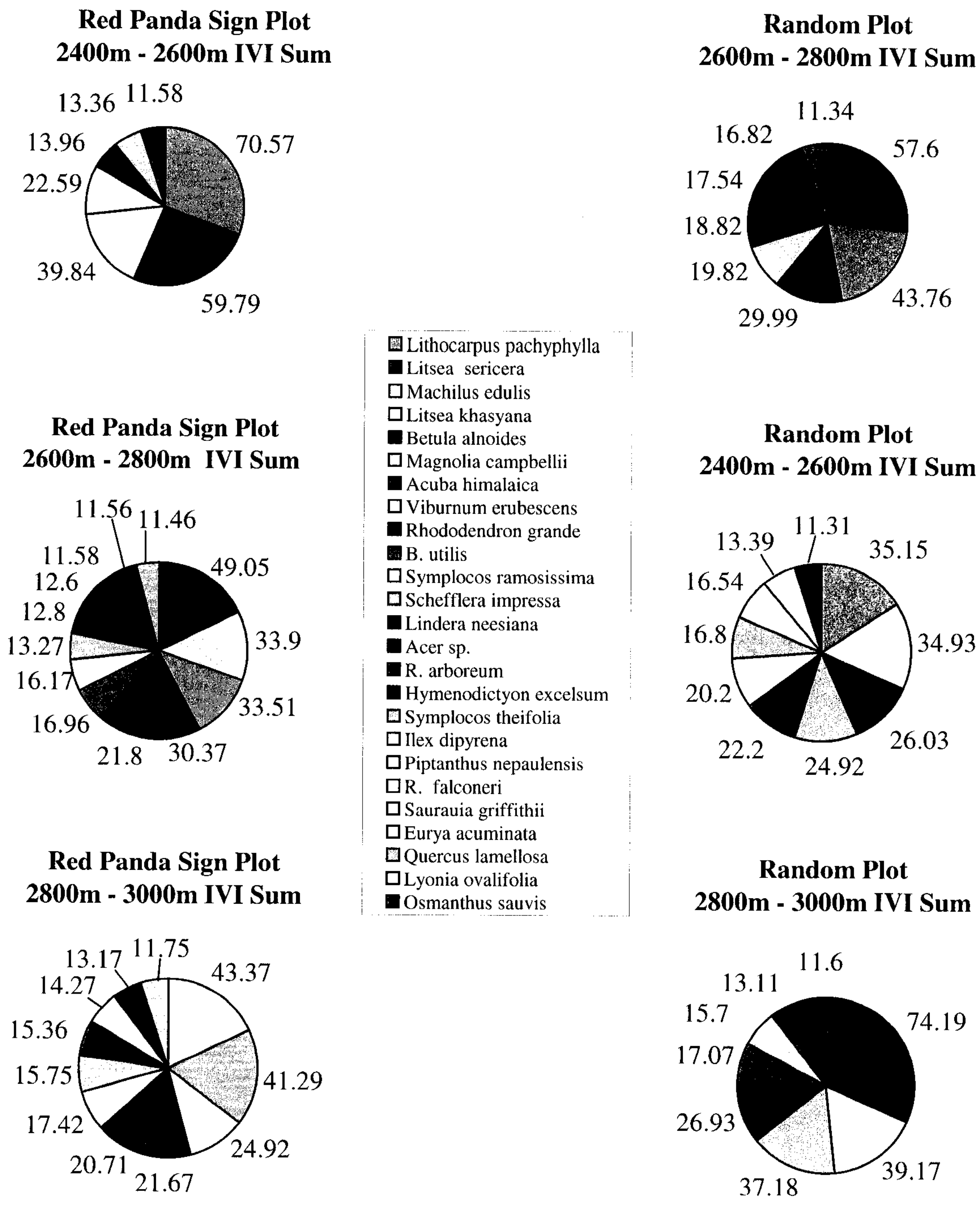

Figure 12. <u>Red Panda Sign and Random Plot Importance Value indicies (IVI) by Altitude</u>. The left is Red Panda sign plot IVIs and the right is Random plot IVIs.

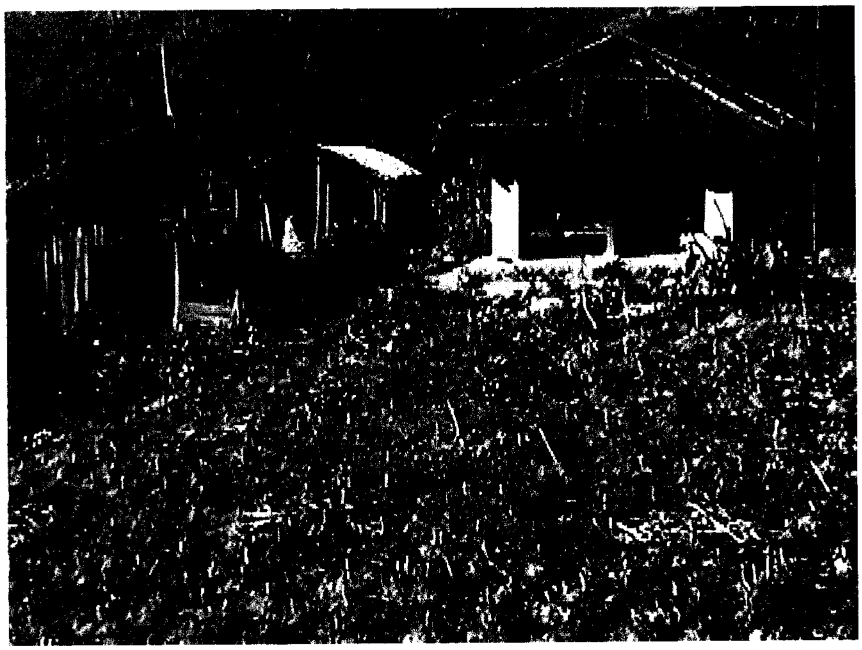

Figure 13. A Nepalese Household: a barn and home. This is a traditional Nepalese *Ghar* (home) with mud and stone walls and a *malingo* (*Arundinaria maling*) roof. The Long whit pieces on the ground are old corn stalks.

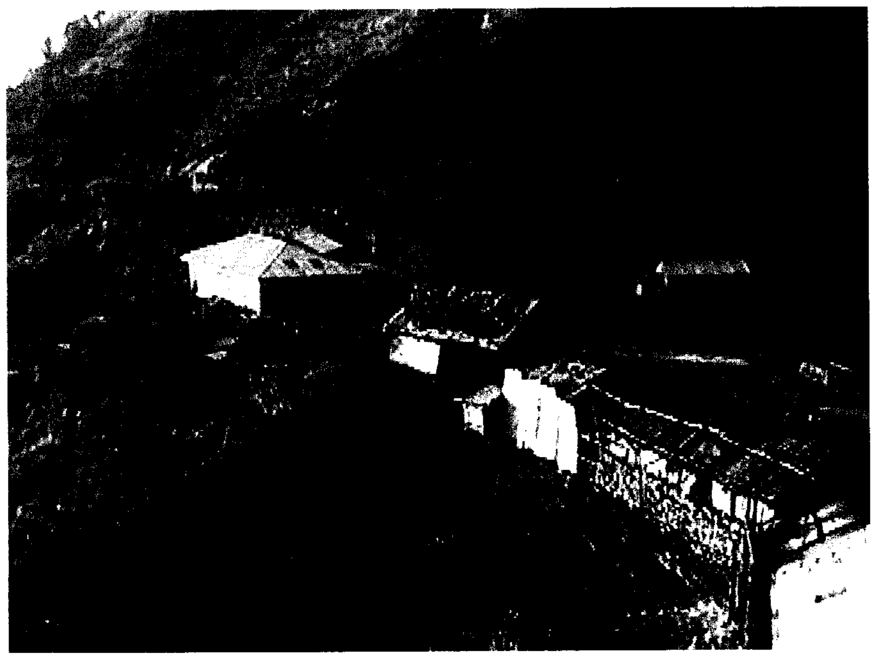

Figure 14. Kaiyakatta Village. This photo shows both thatched (lower right), with the crossbeams lying over the roof, and silver corrugated tin roofing (left). The green on top of the *GoTH* in the middle of the photograph are *Schefflera impresa* leaves, the second most used tree by the red panda and favorite fodder source of Kaiyakatta villagers.

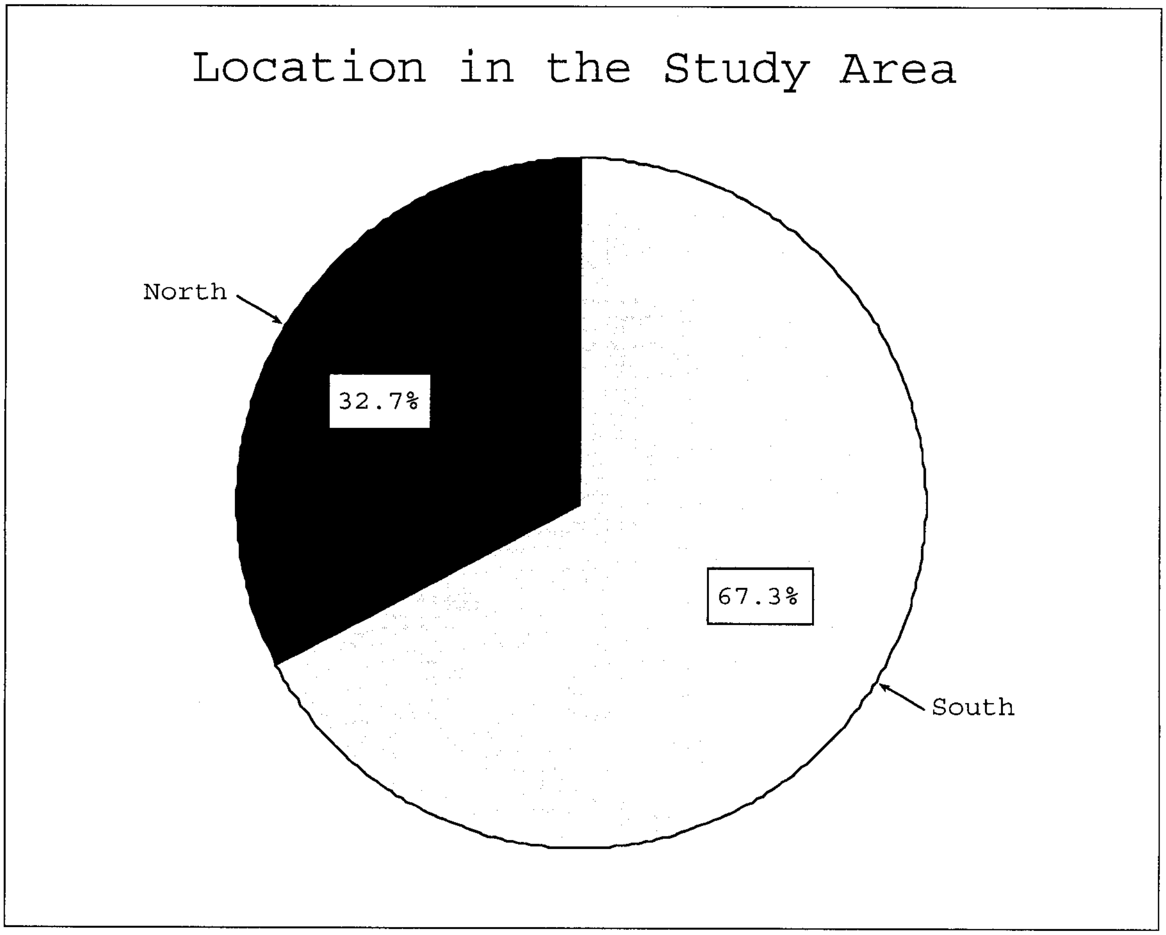

Figure 15. Household Distribution. The percentage of households by location in the study area.

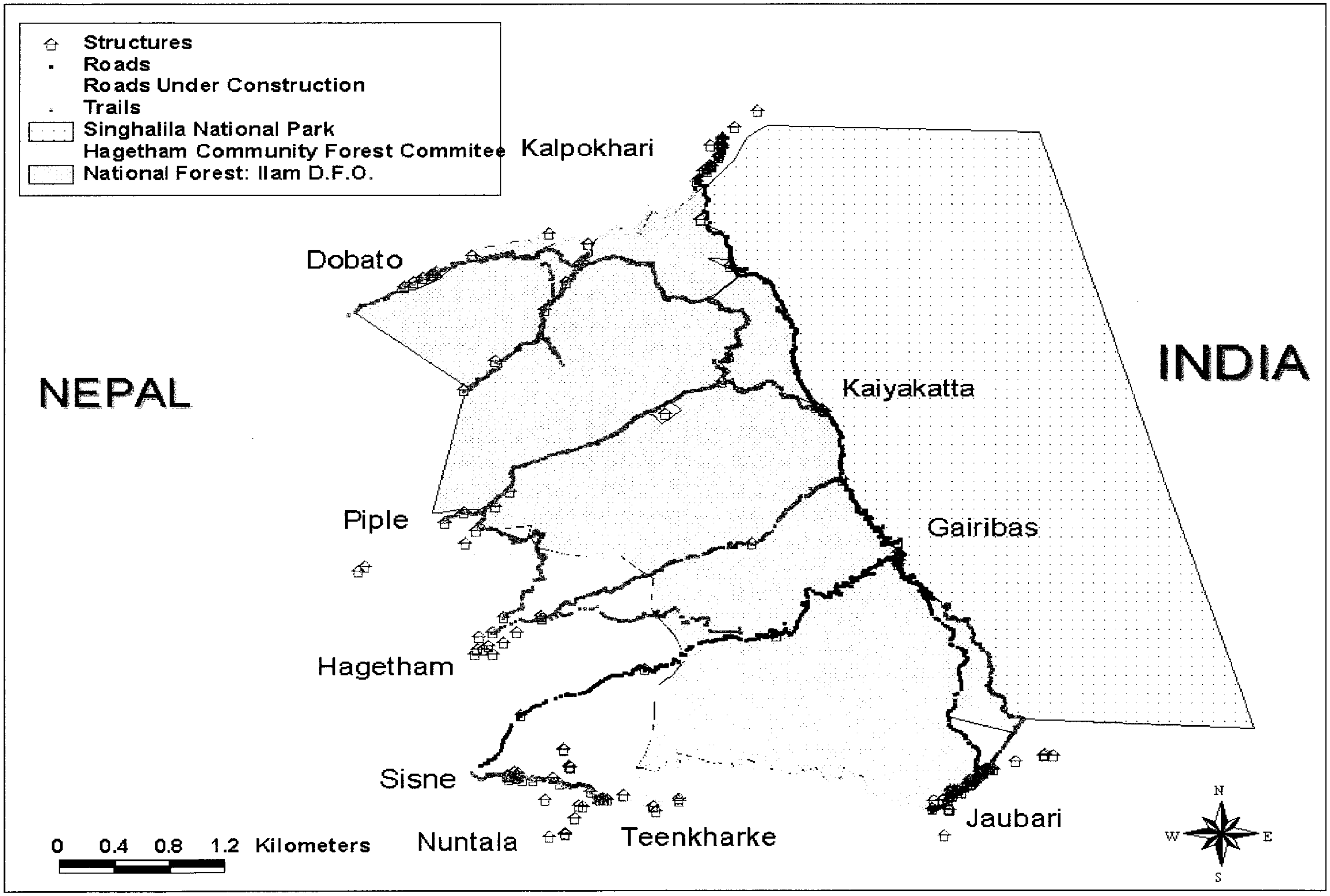

Figure 16. Map of Legal Land Management.

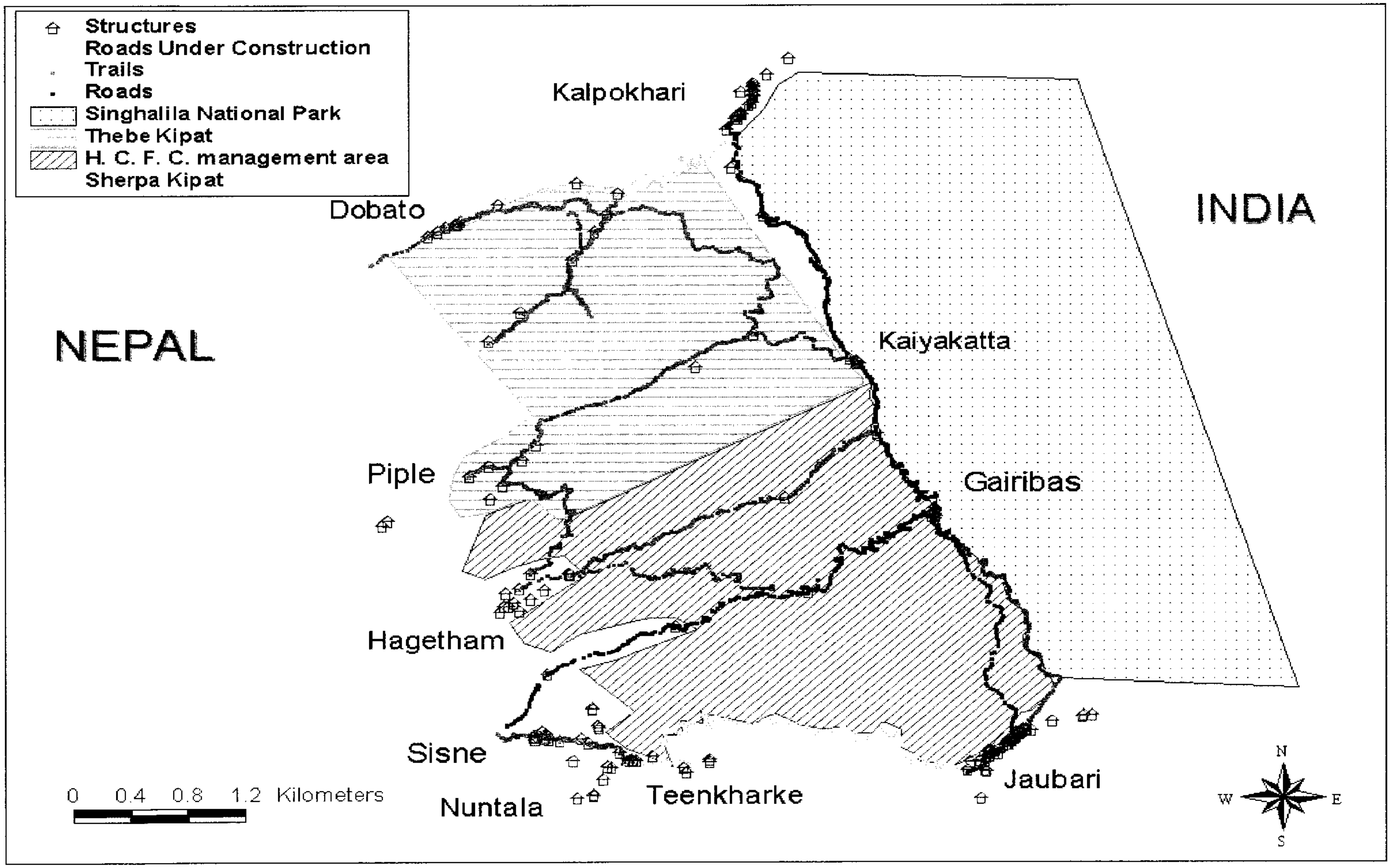

Figure 17. Map of Observed Land Management. This map demonstrates the areas that are under Kipat and Hagetham Community Forest Commmittee management.

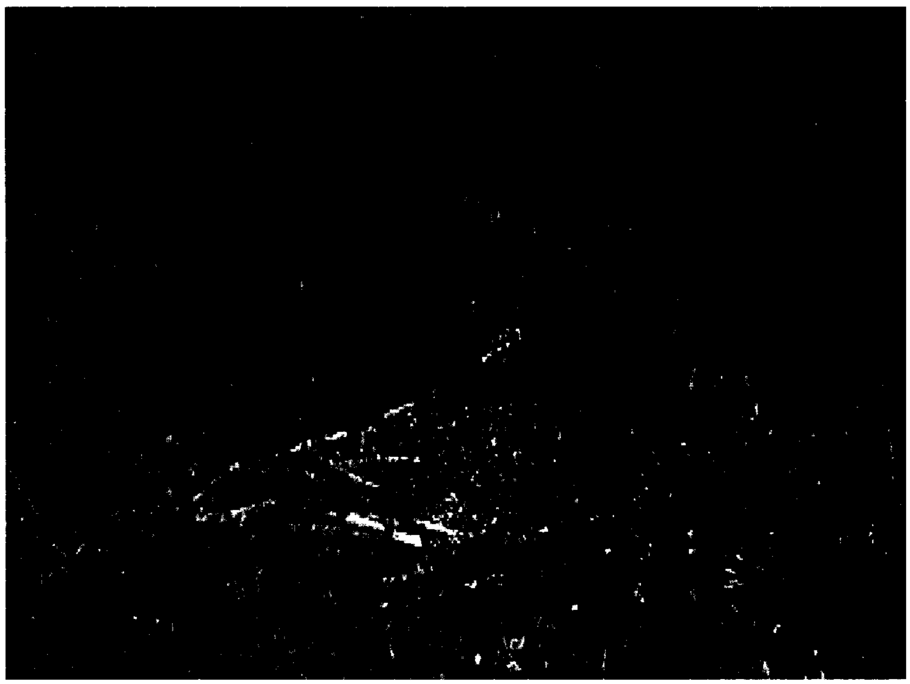

Figure 18. Dobato-Kalpokhari Road Under Construction. First trees are cut then the road is dug. In the center of the photo is a woodpile, the lighter area behind this is the newly dug road. This road has been constructed without having been surveyed by the Ilam District Development Office.

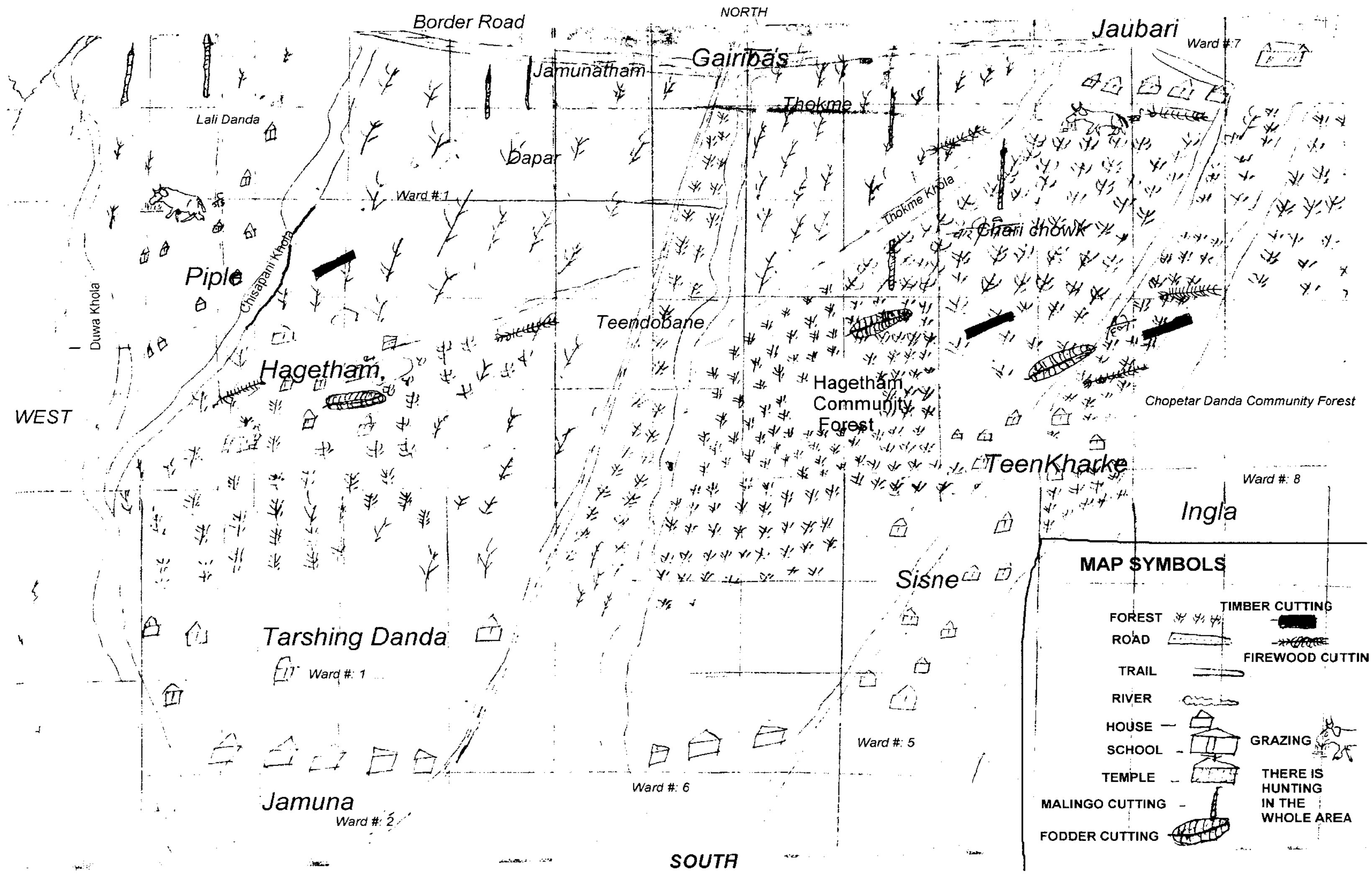

Figure 19. Hagetham Community Forest Committee Participatory Sketch Map.

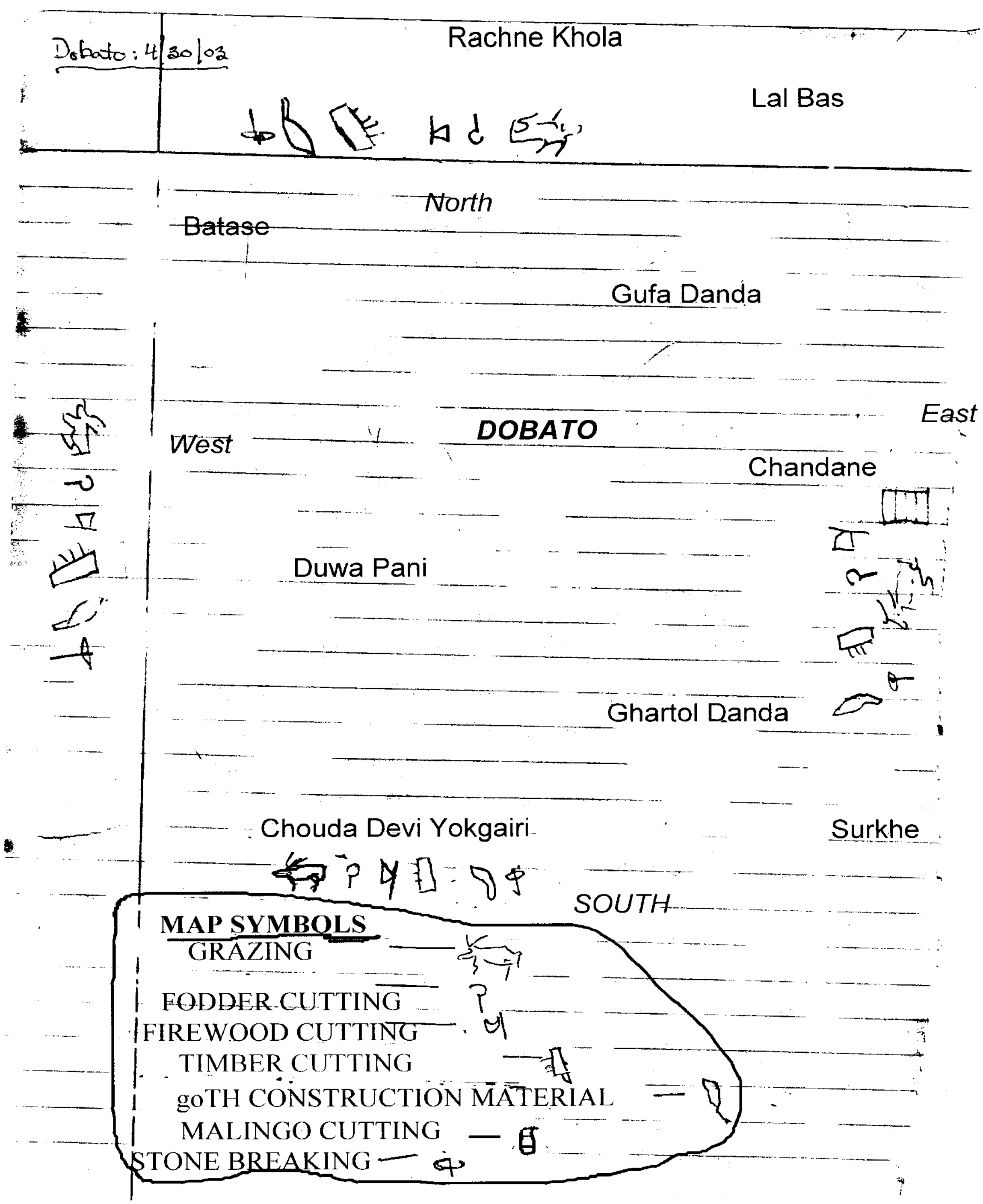

Figure 20. Dobato Participatory Sketch Map. The bottom left shows the land-use symbols. The top symbol is cattle for grazing followed by sickle for fodder cutting, then an axe for firewood cutting, saw for timber cutting, *khukhuri* (a Nepalese knife) for cutting g*oTH* building materials, *malingo* culm for *malingo* cutting, and a mallet for breaking rocks. North is at the top of the map and Dobato is labeled in the center.

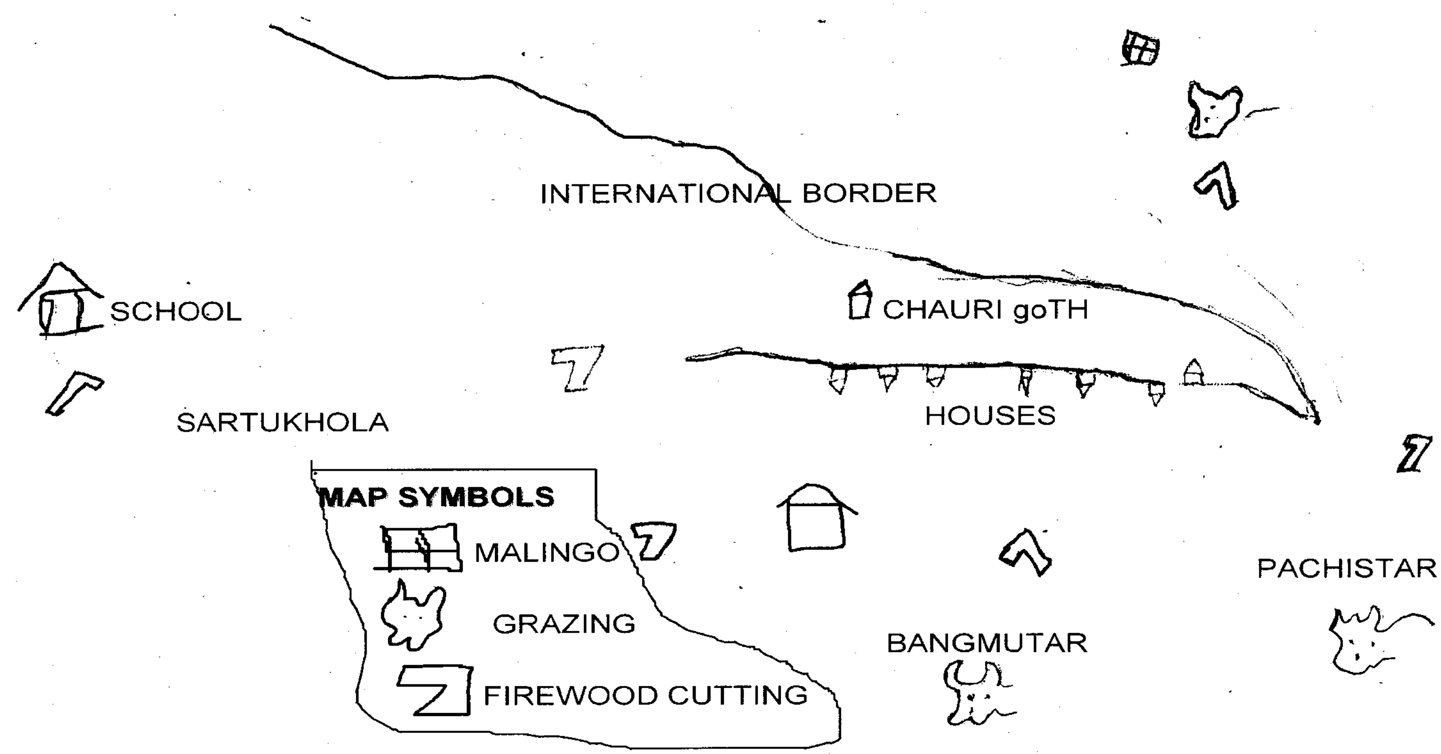

Figure 21. Kalpokhari Participatory Sketch Map.

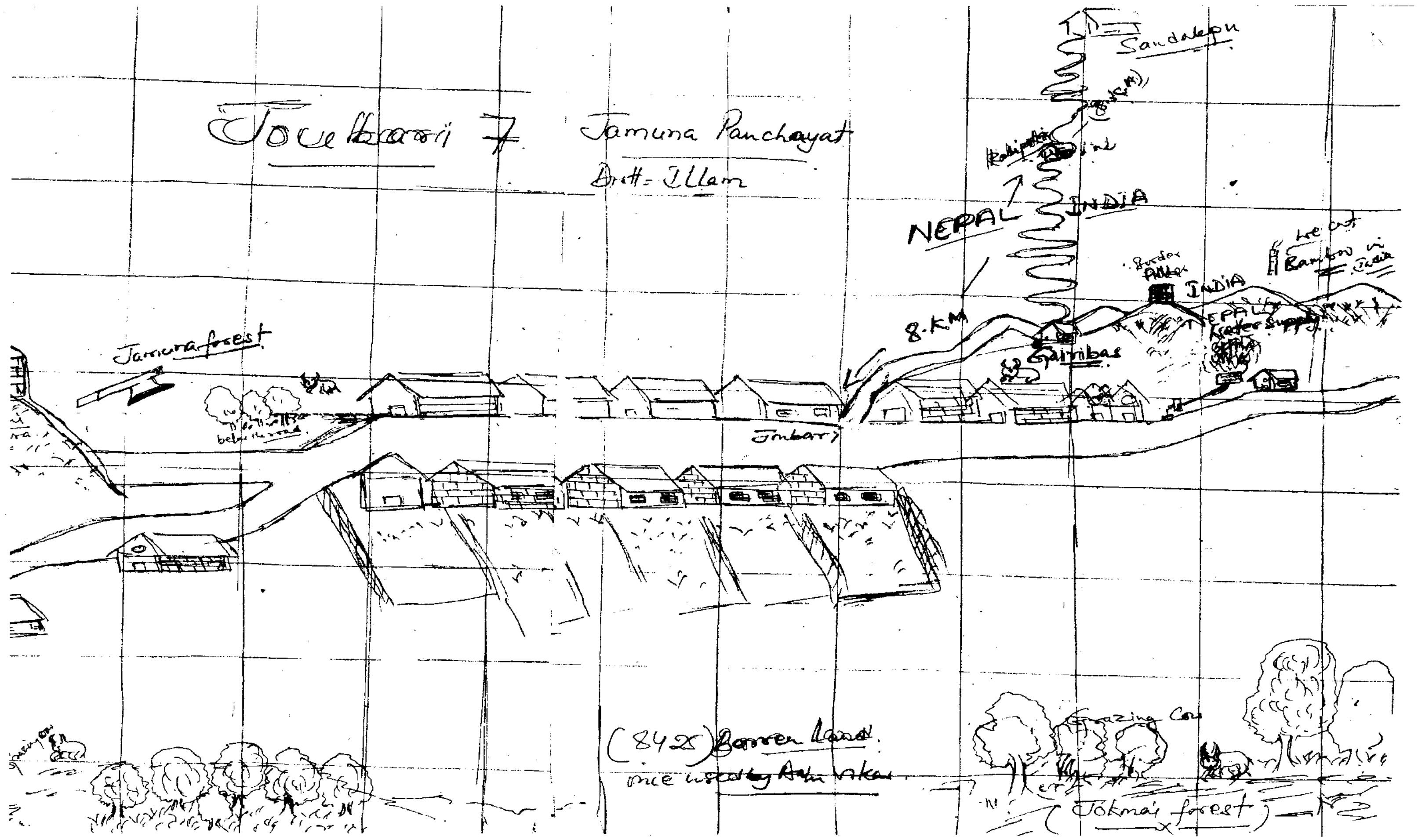

Figure 22. Jaubari Participatory Sketch Map. The axes represent areas where firewood is cut, while the cattle are areas used for grazing. North is to the top of the map.

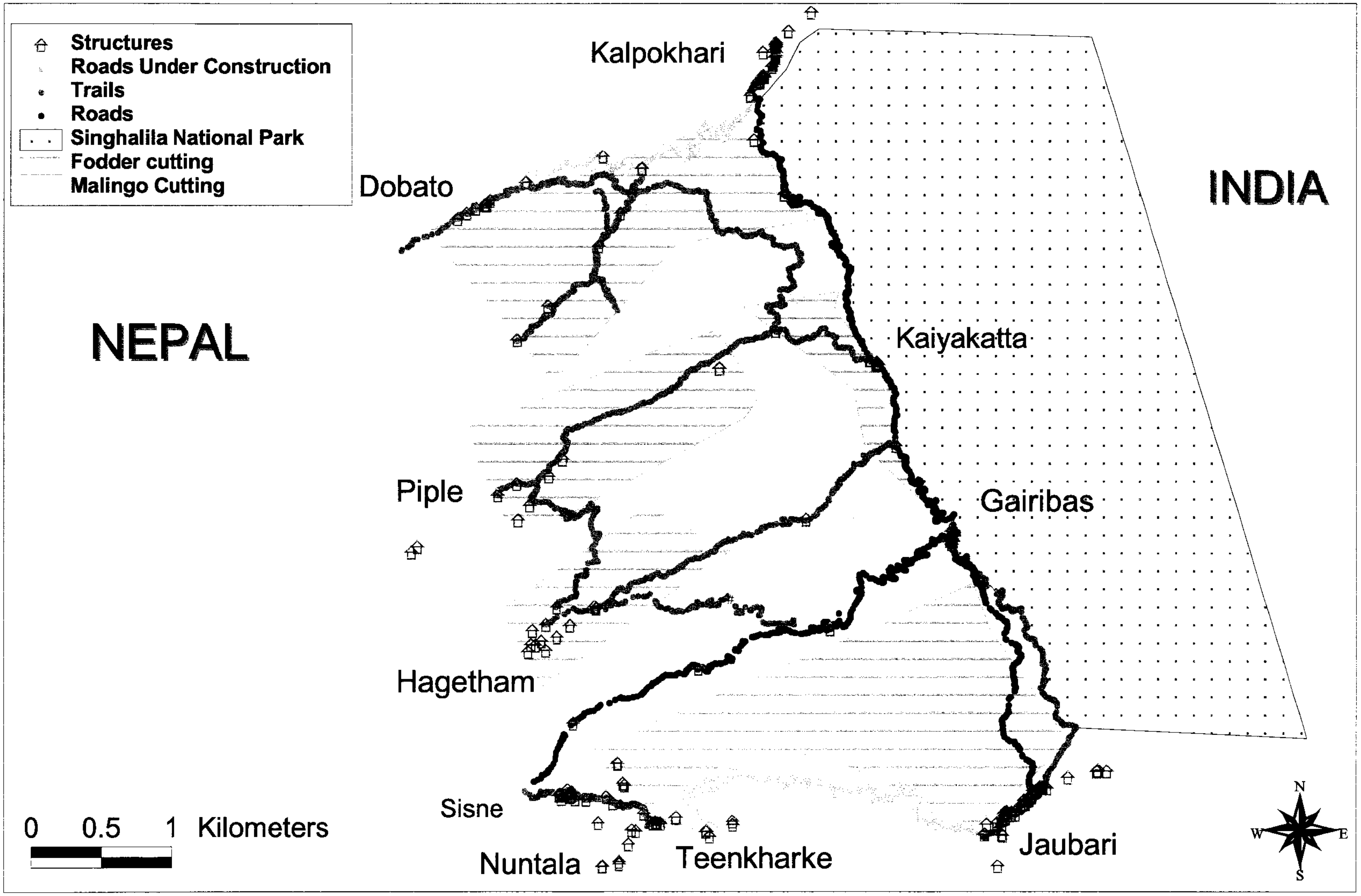

Figure 23. Map of observed malingo and fodder collection locations.

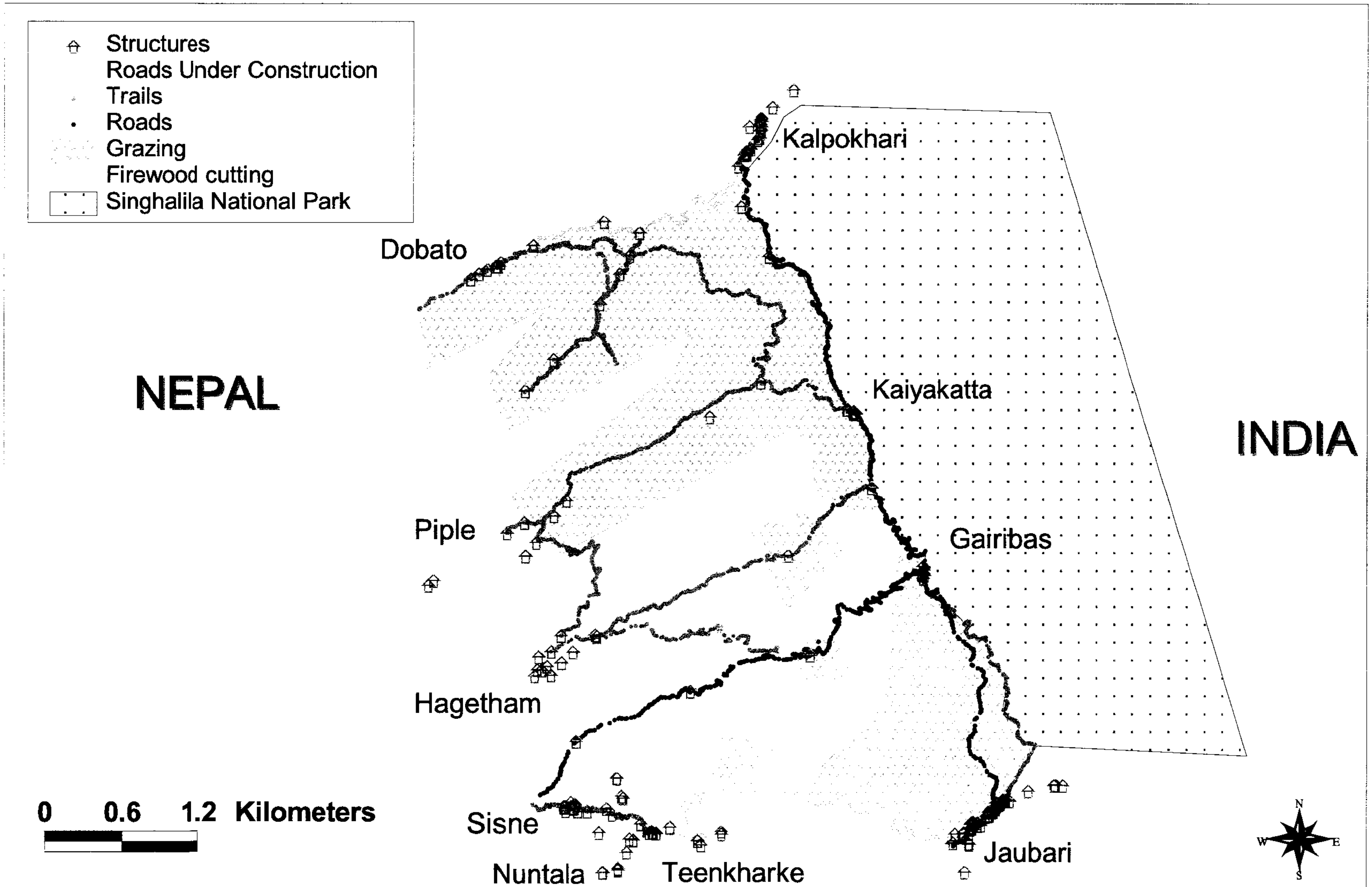

Figure 24. Map of observed firewood cutting and grazing locations.

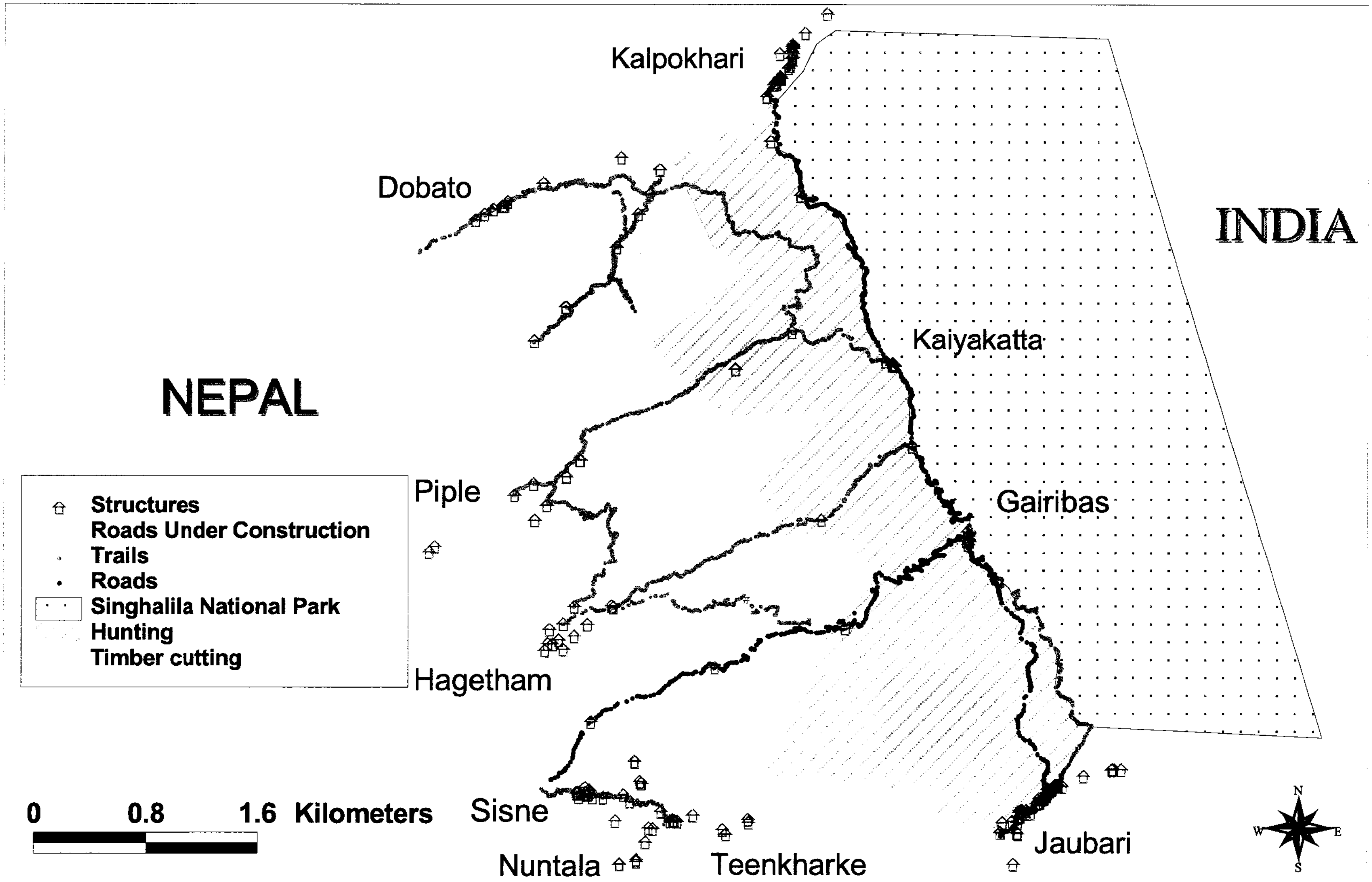

Figure 25. Map of observed hunting and timber cutting locations.

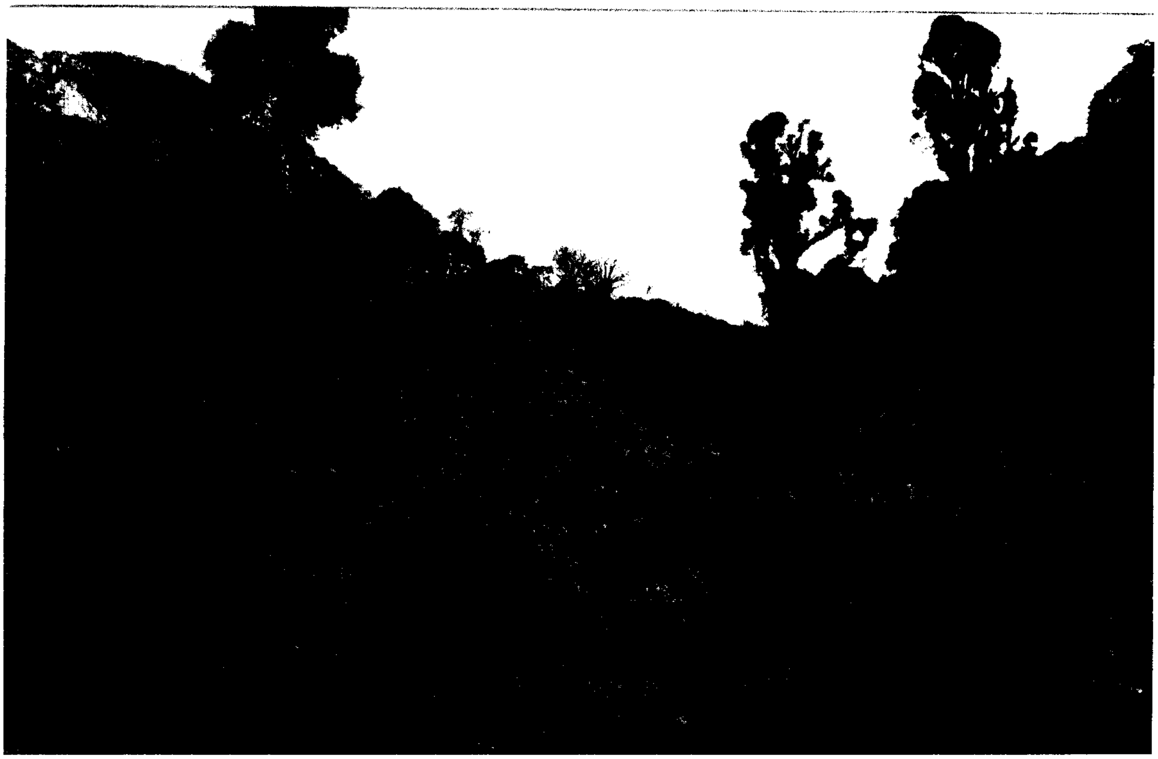

Figure 26. Shrubland. An example of overgrazing 1km southeast of Dobato along the Dobato-Kaiyakatta trail. Twenty-five years ago, this shrubland was mature Eastern Himalayan broadleaf forest with bamboo thickets.

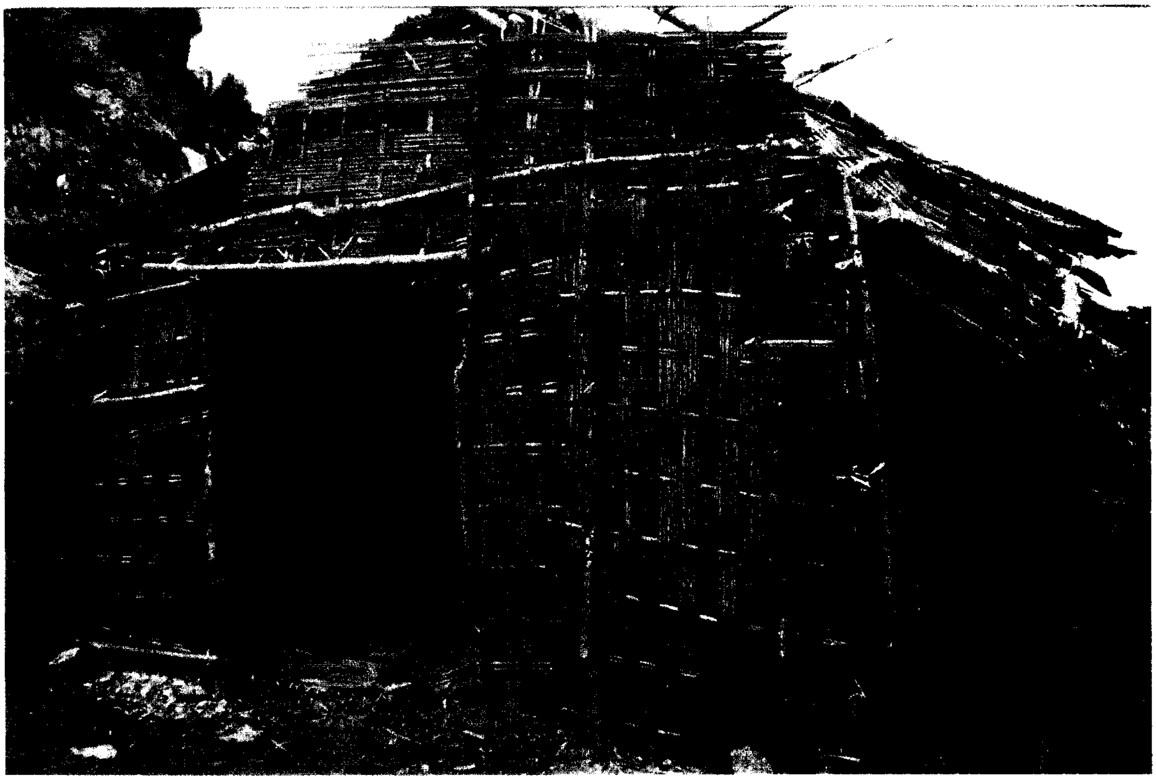

Figure 27. goTH. Nima Pinju Sherpa's cattle herding *goTH* in Kaiyakatta. Usually a *goTH* is torn down after the cowherd moves up or down slope. For the past seven years, this *goTH* has been used by Pinju and his brother, and has yet to be torn down and replaced by a more permanent structure. Pinju said they have not built a more permanent structure because it is on government land and could be torn down by government officials at any moment.

Figure 28. *Malinge.* A *Malinge* tying a load of 60-80 culms of *malingo,* the main food source of the red panda, in a *malingo* thicket. He is using a thin piece of *malingo*, called a *choiya,* to hold the two bundles in place. He will then make a templine called a *namlo* to wrap the load around his head to drag the loads through precut paths in the *malingo* thickets. The author used these precut paths to conduct the ecological and micro-habitat survey.

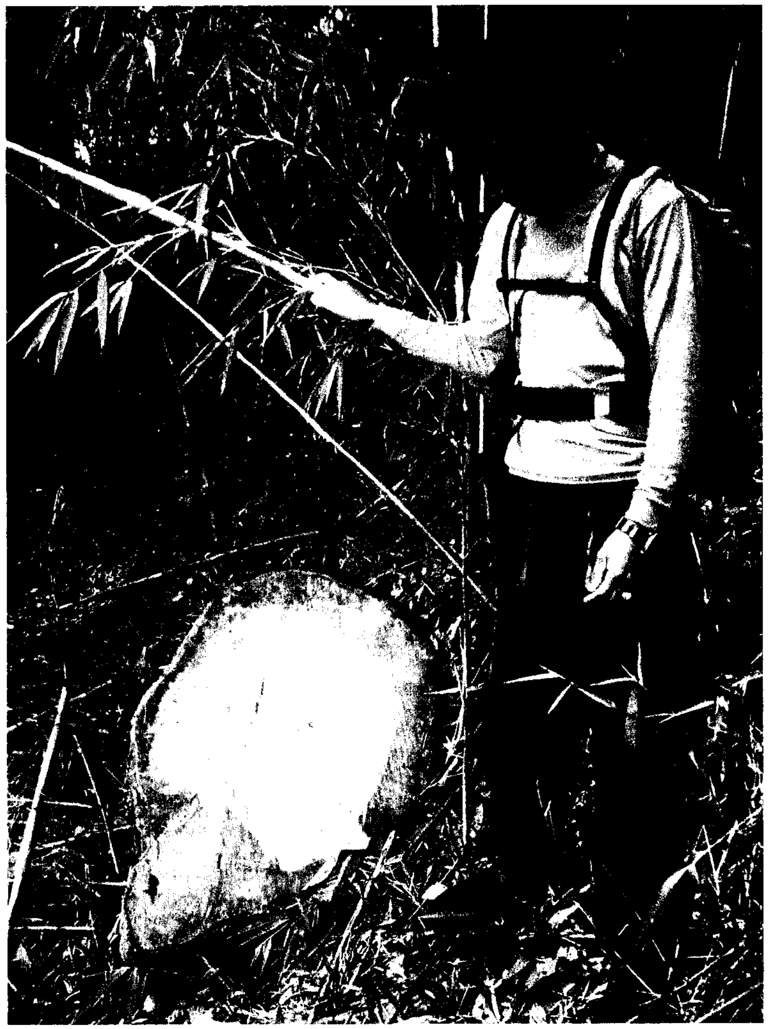

Figure 29. Firewood Cutting. A live half meter in diameter *Lithocarpus pachyphylla* cut for firewood in the jungle half a kilometer below Jaubari.

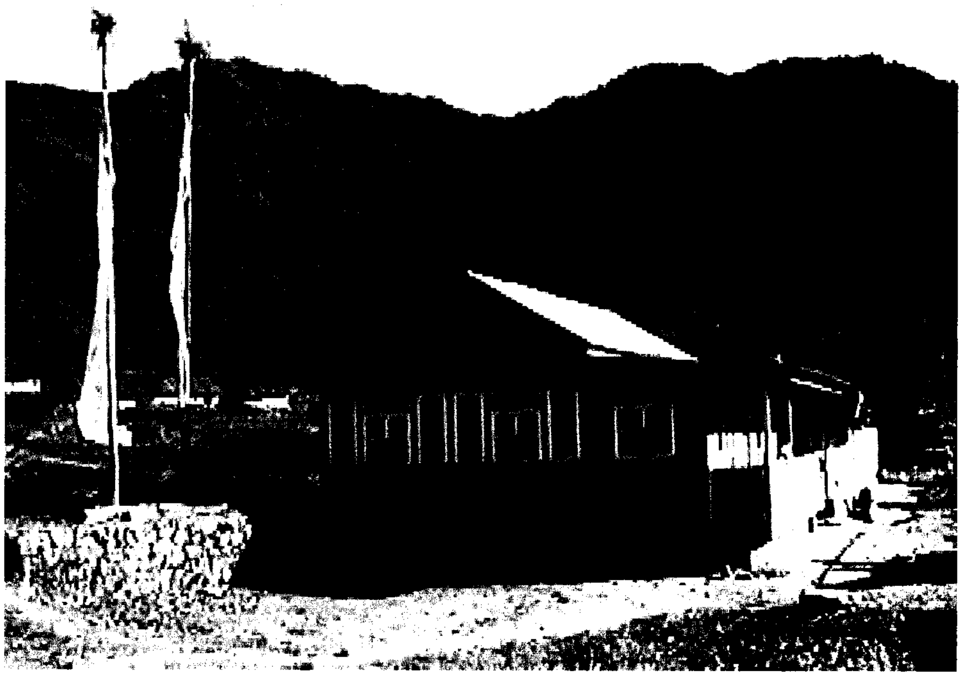

Figure 30. New Hagetham Home. Prem Tamang's newly constructed home in Hagetham. It is made of 2x4 planks and covered with corrugated tin painted blue. Kaiyakatta lies tucked in the pass far in the background.

Figure 31. Improper Fodder Cutting. Improperly lopped *Schefflera impresa*, the second most used tree by the red panda. The stumpy branches in the center of the photograph are dead.

TABLES

Table 1. Disturbance Value. Livestock, *malingo*, and human disturbances were recorded using the following values:

Recorded Value	Percentage of Disturbance
0	0%
1	1% - 25%
2	26% - 50%
3	51% -75%
4	76% -100%

Table 2. Occurrence of Red Panda sign/km by Altitude Zone.

Altitude Zone	Red Panda Sign/km
2400m -2600m	0.56
2600m - 2800m	2.44
2800m - 3000m	5.1

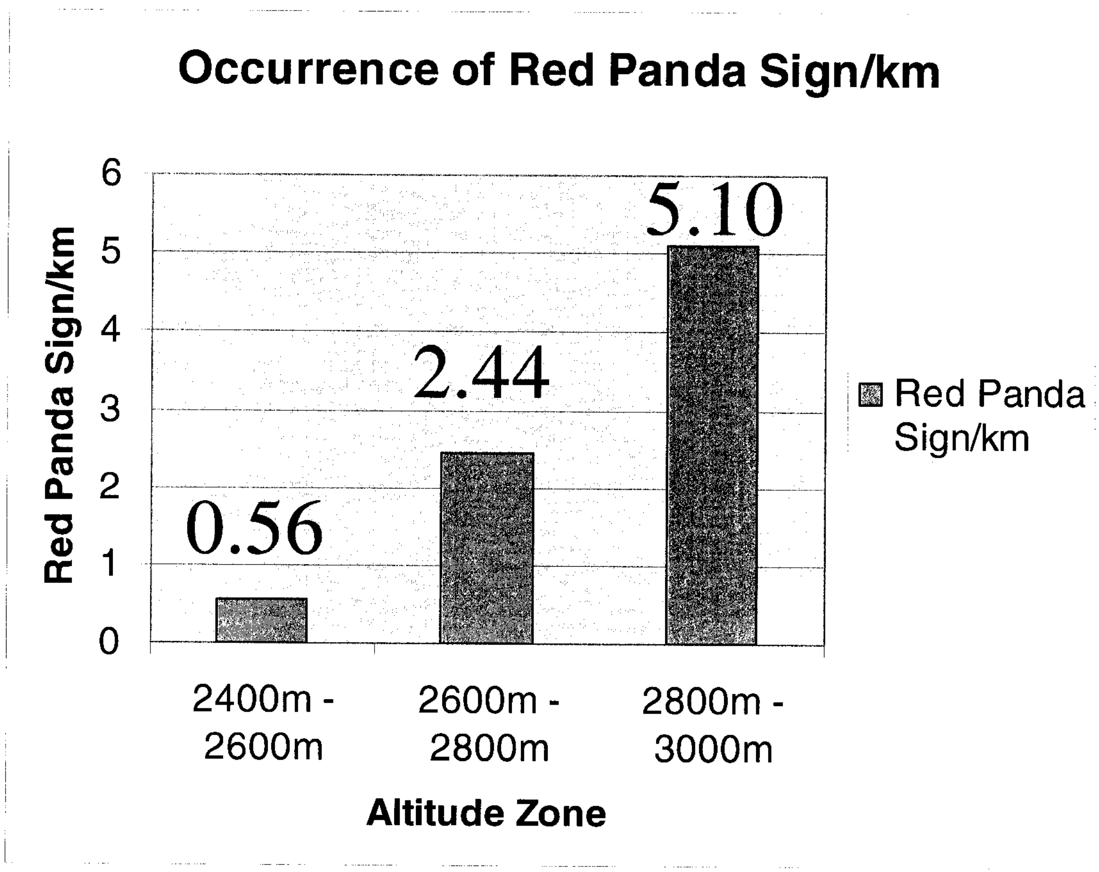

Table 3. Direct and Indirect Red Panda Observations by Altitude. The encounter rate of pellets/day, red panda sightings, total number of field days, and total number of pellets observed in the three altitudinal zones.

	2400m-2600m	2600m-2800m	2800m-3000m
Pellets per day	**7**	**89**	**235**
Red Panda	**1**	**1**	**3**
Total Field Days	**27**	**30**	**12**
Total # of Pellets	**180**	**2664**	**2823**

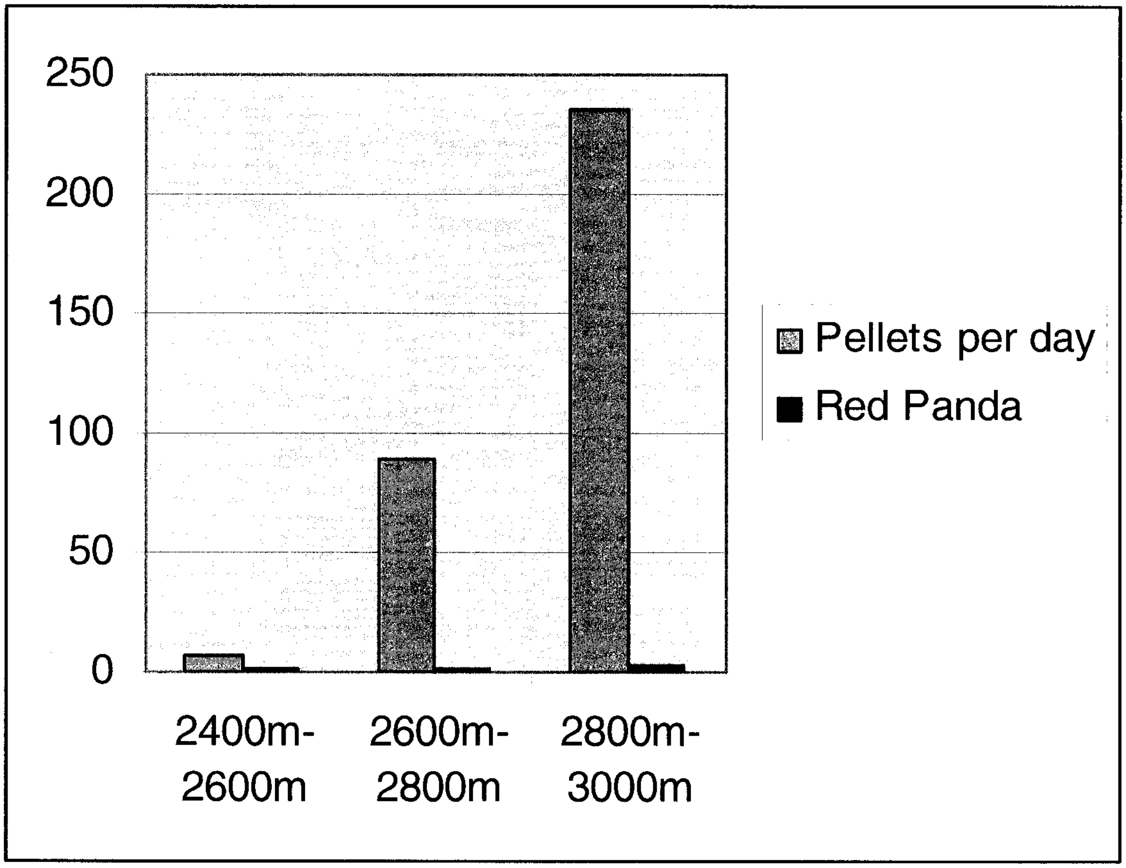

Table 4. Red Panda Pellet Measurements. Number of adult and cub pellets measured in 6 plots during January 2003. The complete measurements are listed in Appendix 3.

Plot	Adult	Cub	Total
1	1	22	23
2	1	7	8
3	0	12	12
4	2	42	44
5	19	24	43
6	12	16	28
Total # of Pellets	35	123	158

Table 5. Microhabitat Plots by Altitude. Altitudinal division of plots measured for the microhabitat survey.

			Plot Type		
			Red Panda Sign	Random	Total
Altitude Zone	2400m-2600m	Count	13	46	59
		% within Altitude Zone	22.0%	78.0%	100.0%
	2600m-2800m	Count	29	22	51
		% within Altitude Zone	56.9%	43.1%	100.0%
	2800m-3000m	Count	14	9	23
		% within Altitude Zone	60.9%	39.1%	100.0%
Total		Count	56	77	133
		% within Altitude Zone	42.1%	57.9%	100.0%

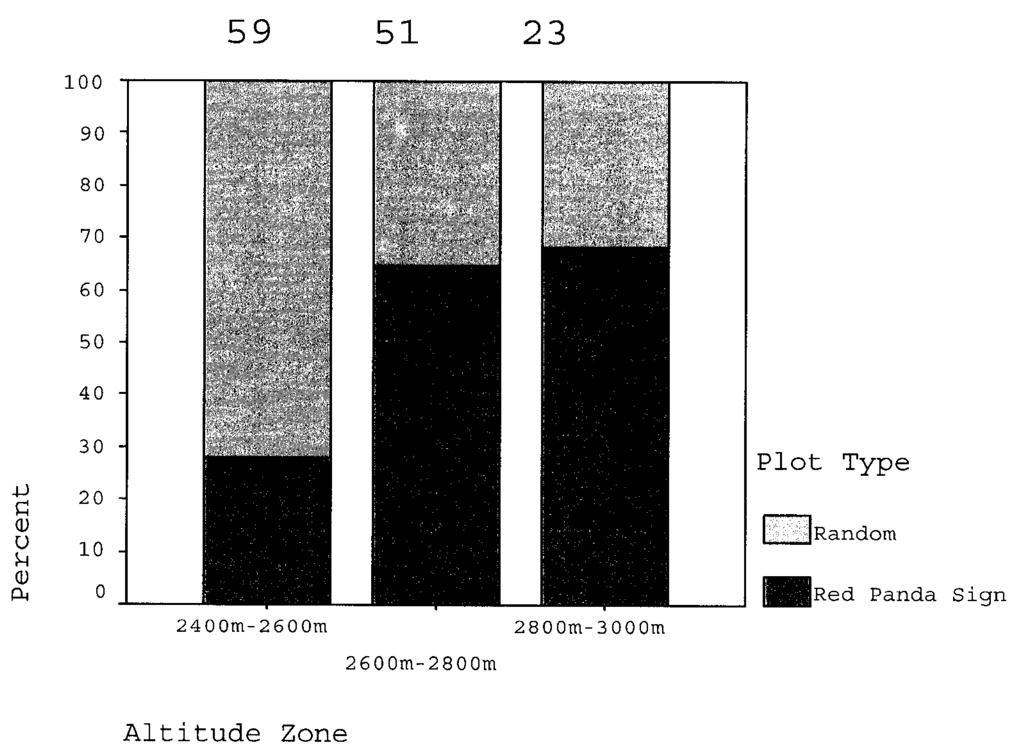

Table 6. Dominant Shrubs for All Plots by Altitude.

Altitude Zone	Random Plots	Red Panda Sign Plots
2400m -2600m	3	2
2600m - 2800m	2	2
2800m - 3000m	2	4

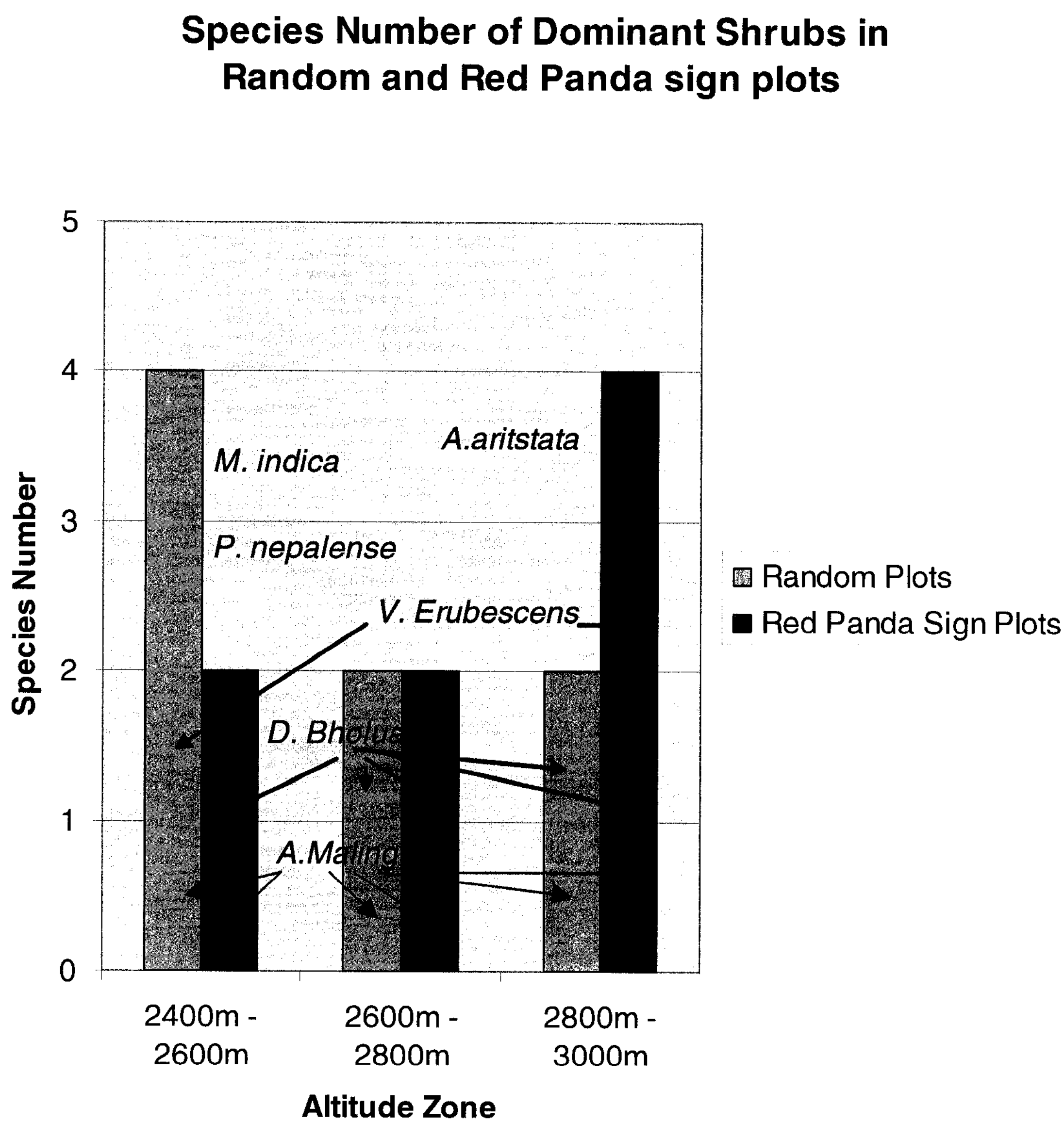

Table 7. Importance Value Index for All Plots by Altitude.

	2400m-2600m Tree Sps	IVI	2600m-2800m Tree sps	IVI	2800m-3000m Tree Sps	IVI
Dominant Upper Canopy	*Acer sp.*	59.20	Litsea sericera	54.65	*Symplocos theifolia*	39.59
	Lithocarpus pachyphylla	45.85	*Lithocarpus pachyphylla*	39.26	*Lindera neesiana*	18.29
	Litsea sericera	31.09	*Rhododendron arboreum*	20.36	*Acer sp.*	16.90
	Machilus edulis	13.41	*Magnolia Campbellii*	13.03	*M. campbellii*	12.73

	2400m-2600m Tree Sps	IVI	2600m-2800m Tree sps	IVI	2800m-3000m Tree Sps	IVI
Dominant Lower Canopy	*Litsea khasyana*	19.62	*Rhododendron grande*	24.99	*Symplocos ramosissima*	50.09
	Eurya acuminata	16.17	*Lindera neesiana*	15.47	*V. erubescens*	41.49
	Rhododendron arboreum	11.28	*Hymenodictyon excelsum*	15.24	*R. arboreum*	40.07
	Acuba himalaica	10.53	*Viburnum erubescens*	15.18	*Ilex dipyrena*	18.98
			Betula utilis	14.93	*H. excelsum*	13.22
			Symplocos ramosissima	13.69	*R. falconeri*	11.08
			Acer sp.	11.13		
			Schefflera impressa	11.06		
			Symplocos theifolia	11.01		

	2400m-2600m	2600m-2800m	2800m-3000m
Dominant Shrubs	Arundinaria maling	A. maling	Piptanthus nepalensis
	Viburnum erubescens	D. bholua	V. erubescens
	Pittosporum nepalense	A. aristata	A.maling
	Daphne bholua		A. artistata
	Morrus indica		D bholua

Table 8. *Arundinaria sp.* Number, Cover, and Average Height for All Plots.

Statistics

		Number of Bamboo per 3x3m plot	Percent Cover per 3x3m plot	Average bamoo height per 3x3m plot
N	Valid	134	130	134
	Missing	0	4	0
Mean		23.32	40.18	2.9233
Std. Error of Mean		1.72	2.88	.1402

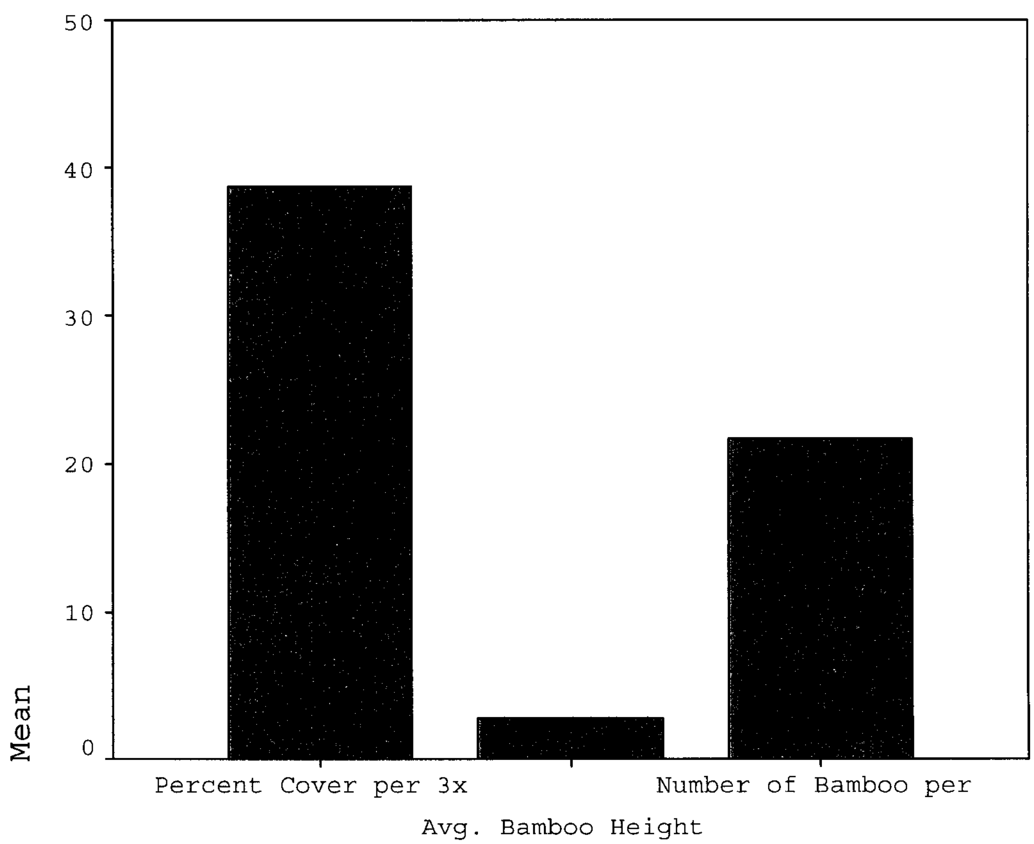

Table 9. Substrate Use. The three substrates used are tree, ground, log, and rock, by season.

Substrate by Season

			Season		
			Winter	Spring	Total
SUBSTRATE	tree	Count	32	47	79
		% within Season	91.4%	66.2%	74.5%
	ground	Count		12	12
		% within Season		16.9%	11.3%
	log	Count	2	3	5
		% within Season	5.7%	4.2%	4.7%
	rock	Count	1	9	10
		% within Season	2.9%	12.7%	9.4%
Total		Count	35	71	106
		% within Season	100.0%	100.0%	100.0%

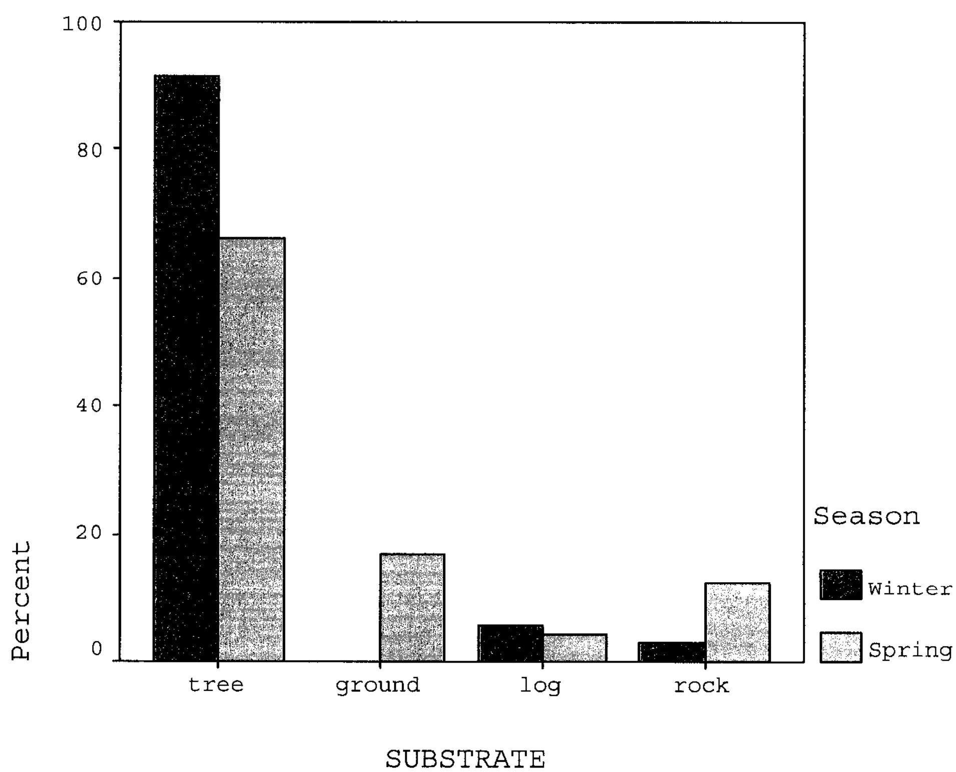

Table 10. Tree Use. Tree species observed with red panda scat. The IVI SUM is taken from all red panda sign plots (Appendix 5). The percentage is based on the number of times red panda scat was observed in that tree species compared to all tree species.

	Tree Species	IVI SUM	Percentage
1	*Lithocarpus pachyphylla*	47.01	24
2	***Schefflera impressa***	**N/A**	**16**
3	*Magnolia campbelli*	29.23	15
4	***Sorbus cuspidata***	**N/A**	**10**
5	*Litsea sericera*	45.15	6
6	*Lindera neesiana*	N/A	6
7	*Betula utilis*	13.27	5
8	*Rhododendron arboreum*	N/A	4
9	*Hymenodictyon excelsum*	N/A	4
10	*Rhododendron falconeri*	N/A	4
11	*Rhododendron grande*	10.24	2
12	*Ilex dipyrena*	26.34	2
13	*Saurauia griffithii*	N/A	2
14	*Evodia fraxinifolia*	N/A	1
15	*Vitex heterophylla*	N/A	1
16	*Lindera pulcherrima*	N/A	1

Table 11. Binary Logistic Regression with All Plots. Binary Logistic Regression model and statistically significant variables with all plots included. The ALTITUDE variable represents all altitudinal zones combined. ALTITUDE(1), which is part of ALTITUDE, represents the 2400m altitude zone. The L.S. variable represents all livestock disturbances values combined. See Table 1 for livestock disturbance values. L.S.(1) only represents one value, no livestock disturbance, and L.S.(4) represents value 3 or 50%-75% livestock disturbance in a plot.

Model				
N=102		**Panda Sign**	**Random**	**% correct**
Plot Type	**Random**	30	13	69.8
	Panda Sign	7	52	88.1
			Total:	**80.4**

Variable	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
ALTITUDE			8.73	2	.01	
ALTITUDE(1)	2.83	1.08	6.89	1	.009	17.05
L.S.			10.44	4	.03	
L.S.(1)	-3.14	1.22	6.59	1	.01	.04
L.S.(4)	-3.61	1.45	6.16	1	.01	.02

Table 12. Binary Logistic Regression with 2400m Plots Excluded. Binary logistic regression model and significant variables when all 2400m plots are dropped from the analysis. In this model, the variable CANOPY_C represents all canopy cover values and L.S.(1) represents plots with no livestock disturbance.

Model				
n=78		**Panda Sign**	**Random**	**% correct**
Plot Type	**Panda Sign**	32	8	80.0
	Random	8	30	78.9
			Total:	**79.5**

	B	**S.E.**	**Wald**	**Df**	**Sig.**	**Exp(B)**
CANOPY_C	.05	.025	.21	1	.022	1.05
L.S.(1)	-3.24	1.72	3.55	3	.05	.03

Table 13. Binary Logisitic Regression with Categorized Variables. Binary logisitical regression model and its significant variables when the variables altitude and aspect are categorized by altitudinal zone and direction. In this model, the variable CANOPY_C represents all canopy cover values, L.S.(1) represents no livestock disturbance, and AVG_DBH represents tree species average DBH.

Model				
n=79		**Panda Sign**	**Random**	**% correct**
Plot Type	**Random**	36	5	87.8
	Panda Sign	6	32	84.2
			Total:	86.1

Variable	**B**	**S.E.**	**Wald**	**df**	**Sig.**	**Exp(B)**
CANOPY_C	.08	.036	.34	2	.011	.08
L.S.(1)	4.73	2.05	5.32	1	.02	.01
AVG._DBH	.02	.013	.86		.04	1.02

Table 14. Land Ownership by Location. Crosstabulation of number of ropani of land owned per household by location in the study area.

			Land (ropani)			
			0	1 to 10	11 or more	Total
Location in the Study Area	North Study Area	Count	7	16	5	28
		% within Location in the Study Area	25.0%	57.1%	17.9%	100.0%
	South Study Area	Count	12	20	23	55
		% within Location in the Study Area	21.8%	36.4%	41.8%	100.0%
Total		Count	19	36	28	83
		% within Location in the Study Area	22.9%	43.4%	33.7%	100.0%

Table 15. Type of Roof by Location. Crosstabulation of the type of roof, malingo or corrugated tin, by the location in the study area.

			Type of roof		
			Malingo	Tin	Total
Location in the Study Area	North Study Area	Count	24	13	37
		% within Location in the Study Area	64.9%	35.1%	100.0%
	South Study Area	Count	43	33	76
		% within Location in the Study Area	56.6%	43.4%	100.0%
Total		Count	67	46	113
		% within Location in the Study Area	59.3%	40.7%	100.0%

Table 16. Household Demographics. Percentages are based on reported number of inhabitants.

PLACE	% Male (#)	% Female (#)	# of Inhabit-ants	# of Households	Inhabitants per Household	Avg. Male Age	Avg. Female age
Kalpokhari	48 (23)	52 (25)	27	10	2.70	23.74	20.41
Dobato	55 (34)	45 (28)	54	14	3.86	41.82	31.19
Piple	56 (23)	44 (18)	41	8	5.13	28.92	33.85
Kaiyakatta	58 (11)	42 (8)	19	5	3.80	24.07	26.20
North Study Area	***54 (91)***	***46 (79)***	***141***	***37***	***3.81***	***29.64***	***27.91***
Sisne	58 (39)	42 (28)	63	12	5.25	26.62	31.02
Nuntala	54 (28)	46 (24)	52	7	7.43	27.04	29.77
Teenkharke	45 (15)	55 (18)	33	5	6.60	26.31	28.72
Gairibas	41 (19)	49 (18)	31	6	5.17	27.10	21.63
Hagetham	55 (32)	45 (26)	52	10	5.20	24.01	20.58
Jaubari	53 (90)	47 (80)	133	36	3.69	32.46	33.25
South Study Area	***53 (223)***	***47 (194)***	***364***	***76***	***4.79***	***27.26***	***27.49***
TOTAL	53 (314)	47 (273)	505	113	4.47	28.45	27.70

Table 17. Religious Group Chi-Square. Chi-Square Test of religious group by location in the study area.

Crosstab

			Religious Group			
			Kirat	Bhuddist	Hindu	Total
Location in Study Area	South Study Area	Count	7	61	8	76
		Expected Count	11.4	58.5	6.1	76.0
		% within Location in Study Area	9.2%	80.3%	10.5%	100.0%
		Adjusted Residual	-2.5	1.2	1.4	
	North Study Area	Count	10	26	1	37
		Expected Count	5.6	28.5	2.9	37.0
		% within Location in Study Area	27.0%	70.3%	2.7%	100.0%
		Adjusted Residual	2.5	-1.2	-1.4	
Total		Count	17	87	9	113
		Expected Count	17.0	87.0	9.0	113.0
		% within Location in Study Area	15.0%	77.0%	8.0%	100.0%
		Adjusted Residual				

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.486[a]	2	.024
Continuity Correction			
Likelihood Ratio	7.476	2	.024
Linear-by-Linear Association	7.204	1	.007
N of Valid Cases	113		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 2.95.

Table 18. Household and Resource-Use Demographics . Percentages are based on the reported number of inhabitants.

PLACE	# of Inhabitants	# of Households	% educated(#)	% Outside of Village (#)	Avg. Monthly Expenses	Avg. Firewood usage per month	Avg. Malingo usage per year
Kalpokhari	27	10	44(21)	44(21)	2744	18	486
Dobato	54	14	47(29)	13(8)	2564	24	1404
Piple	41	8	29(12)	0	3625	16	829
Kaiyakatta	19	5	53(10)	0	2328	36	1725
North Study Area	*141*	*37*	*42(72)*	*17(29)*	*2815*	*24*	*1111*
Sisne	63	12	51(34)	6(4)	2922	15	557
Nuntala	52	7	46(24)	0	3014	17	914
Teenkharke	33	5	61(20)	0	4000	30	1020
Gairibas	31	6	68(25)	16(6)	1967	26	875
Hagetham	52	10	21(12)	10(6)	1700	13	1700
Jaubari	133	36	62(105)	22(37)	3459	14	726
outh Study Area	*364*	*76*	*53(220)*	*13(53)*	*2844*	*19*	*965*
TOTAL	505	113	50(292)	14(82)	2830	21	1038

Table 19. Primary Income Source Distribution. The distribution of primary income sources in the north and south study area

			What are your income sources?					
			Business	Government job	Livestock	labour	Farming	Total
Location in the Study Area	South Study Area	Count	11	3	26	12	15	67
		% within Location in the Study Area	16.4%	4.5%	38.8%	17.9%	22.4%	100%
	North Study Area	Count	5	1	21		7	34
		% within Location in the Study Area	14.7%	2.9%	61.8%		20.6%	100%
Total		Count	16	4	47	12	22	101
		% within Location in the Study Area	15.8%	4.0%	46.5%	11.9%	21.8%	100%

Table 20. <u>Secondary Income Source Distribution.</u> The distribution of secondary income sources in the north and south study area.

			What are your other income sources (2)?					
			Business	Government Job	Livestock	Labour	Farming	Total
Location in the Study Area	South Study Area	Count	4	3	12	4	17	40
		% within Location in the Study Area	10.0%	7.5%	30.0%	10.0%	42.5%	100.0%
	North Study Area	Count	3		5	2	9	19
		% within Location in the Study Area	15.8%		26.3%	10.5%	47.4%	100.0%
Total		Count	7	3	17	6	26	59
		% within Location in the Study Area	11.9%	5.1%	28.8%	10.2%	44.1%	100.0%

Table 21. Tertiary Income Source Distribution. Distribution of tertiary income sources in the north and south study area.

			What are your other income sources (3)?						
			Business	Government Job	Livestock	Labour	Farming	Foreign Wage	Total
Location in the Study Area	South Study Area	Count	2	1	2	2	2	1	10
		% within Locatior in the Study Area	20.0%	10.0%	20.0%	20.0%	20.0%	10.0%	100%
	North Study Area	Count	1			3	2		6
		% within Locatior in the Study Area	16.7%			50.0%	33.3%		100%
Total		Count	3	1	2	5	4	1	16
		% within Locatior in the Study Area	18.8%	6.3%	12.5%	31.3%	25.0%	6.3%	100%

Table 22. Food Sustainability Chi-Square.

			How many months does your food last?			
			0-2	3-4	5-12	Total
Location in the study area	South Study Area	Count	13	30	24	67
		Expected Count	18.4	25.6	23.0	67.0
		% within Location in the study area	19.4%	44.8%	35.8%	100.0%
	North Study Area	Count	15	9	11	35
		Expected Count	9.6	13.4	12.0	35.0
		% within Location in the study area	42.9%	25.7%	31.4%	100.0%
Total		Count	28	39	35	102
		Expected Count	28.0	39.0	35.0	102.0
		% within Location in the study area	27.5%	38.2%	34.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	6.921[a]	2	.031
Continuity Correction			
Likelihood Ratio	6.808	2	.033
Linear-by-Linear Association	2.880	1	.090
N of Valid Cases	102		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.61.

Table 23. Food Security Cross-tabulation: percentage and number of households that take out a loan to feed themselves.

			Do you have to take out a loan to eat?		
			No	Yes	Total
Location in the study area	South Study Area	Count	18	52	70
		Expected Count	20.7	49.3	70.0
		% within Location in the study area	25.7%	74.3%	100.0%
	North Study Area	Count	13	22	35
		Expected Count	10.3	24.7	35.0
		% within Location in the study area	37.1%	62.9%	100.0%
Total		Count	31	74	105
		Expected Count	31.0	74.0	105.0
		% within Location in the study area	29.5%	70.5%	100.0%

Table 24. <u>2003 Income Status</u>. The percentage and number of households that had an increase or decrease in income last year.

			Have you had an increase or decrease in income the last year?		
			decrease	increase	Total
Location in the study area	South Study Area	Count	48	8	56
		Expected Count	42.3	13.7	56.0
		% within Location in the study area	85.7%	14.3%	100.0%
	North Study Area	Count	17	13	30
		Expected Count	22.7	7.3	30.0
		% within Location in the study area	56.7%	43.3%	100.0%
Total		Count	65	21	86
		Expected Count	65.0	21.0	86.0
		% within Location in the study area	75.6%	24.4%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	8.931[b]	1	.003		
Continuity Correction [a]	7.426	1	.006		
Likelihood Ratio	8.621	1	.003		
Fisher's Exact Test				.004	.004
Linear-by-Linear Association	8.827	1	.003		
N of Valid Cases	86				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.33.

Table 25. Perceived Grazing Regulation.

Crosstab

			Has grazing been stopped?		
			No	Yes	Total
Location in the study area	South Study Area	Count	45	19	64
		Expected Count	47.0	17.0	64.0
		% within Location in the study area	70.3%	29.7%	100.0%
	North Study Area	Count	27	7	34
		Expected Count	25.0	9.0	34.0
		% within Location in the study area	79.4%	20.6%	100.0%
Total		Count	72	26	98
		Expected Count	72.0	26.0	98.0
		% within Location in the study area	73.5%	26.5%	100.0%

Table 26. Perceived Firewood Cutting Regulation.

			How long is firewood purji open each year?			
			one month	2 months	3 or more months	Total
Location in the study area	South Study Area	Count	26	2	44	72
		% within Location in the study area	36.1%	2.8%	61.1%	100.0%
	North Study Area	Count	12		23	35
		% within Location in the study area	34.3%		65.7%	100.0%
Total		Count	38	2	67	107
		% within Location in the study area	35.5%	1.9%	62.6%	100.0%

Table 27. Perceived Timber Cutting Regulation.

			How long is timber purji open each year?				
			0 months	1 month	2 months	3 or more months	Total
Location in the study area	South Study Area	Count	6	41	1	24	72
		Expected Count	15.5	36.3	.7	19.5	72.0
		% within Location in the study area	8.3%	56.9%	1.4%	33.3%	100.0%
	North Study Area	Count	17	13	0	5	35
		Expected Count	7.5	17.7	.3	9.5	35.0
		% within Location in the study area	48.6%	37.1%	.0%	14.3%	100.0%
Total		Count	23	54	1	29	107
		Expected Count	23.0	54.0	1.0	29.0	107.0
		% within Location in the study area	21.5%	50.5%	.9%	27.1%	100.0%

Table 28. Perceived Reforestation Chi-Square.

Crosstab

			Have you seen any trees planted in the last year?		
			No	Yes	Total
Location in the Study Area	South Study Area	Count	23	42	65
		Expected Count	35.8	29.3	65.0
		% within Location in the Study Area	35.4%	64.6%	100.0%
	North Study Area	Count	32	3	35
		Expected Count	19.3	15.7	35.0
		% within Location in the Study Area	91.4%	8.6%	100.0%
Total		Count	55	45	100
		Expected Count	55.0	45.0	100.0
		% within Location in the Study Area	55.0%	45.0%	100.0%

Table 29. Livestock Head Per Household Chi-Square.

			Livestock			
			4 or less	5 to 9	10 and above	Total
Location in the Study Area	North Study Area	Count	9	3	25	37
		Expected Count	12.1	10.8	14.1	37.0
		% within Location in the Study Area	24.3%	8.1%	67.6%	100.0%
	South Study Area	Count	28	30	18	76
		Expected Count	24.9	22.2	28.9	76.0
		% within Location in the Study Area	36.8%	39.5%	23.7%	100.0%
Total		Count	37	33	43	113
		Expected Count	37.0	33.0	43.0	113.0
		% within Location in the Study Area	32.7%	29.2%	38.1%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	19.957[a]	2	.000
Continuity Correction			
Likelihood Ratio	20.855	2	.000
Linear-by-Linear Association	10.814	1	.001
N of Valid Cases	109		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.84.

Table 30. Livestock Head Per Household T-Test.

Group Statistics

	Location in Study Area	N	Mean	Std. Deviation	Std. Error Mean
LIVESTOCK	South Study Area	76	7.75	8.03	.92
	North Study Area	37	13.11	10.06	1.65

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
LIVESTOCK	Equal variances assumed	4.128	.045	-3.059	111	.003	-5.36	1.75	-8.83	-1.89
	Equal variances not assumed			-2.831	59.062	.006	-5.36	1.89	-9.14	-1.57

Table 31. *Malingo* Usage and Availability. Household yearly malingo usage and estimated current availability.

Avg. Household Usage/ year	# of Households	*# of culms used/year*
1038	113	117,294
Avg. # culms 3x3 m plot	*Area with Malingo (km^2)*	*# of Malingo culms available*
23 ± 20	12	30,667 – 57, 319

Table 32. Firewood Collection Location Chi-Square.

Crosstab

			Where do you cut your firewood?		
			Community Forest	National Forest	Total
Location in the Study Area	South Study Area	Count	52	18	70
		Expected Count	37.1	32.9	70.0
		% within Location in the Study Area	74.3%	25.7%	100.0%
	North Study Area	Count	11	38	49
		Expected Count	25.9	23.1	49.0
		% within Location in the Study Area	22.4%	77.6%	100.0%
Total		Count	63	56	119
		Expected Count	63.0	56.0	119.0
		% within Location in the Study Area	52.9%	47.1%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	31.088[b]	1	.000		
Continuity Correction [a]	29.042	1	.000		
Likelihood Ratio	32.562	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	30.826	1	.000		
N of Valid Cases	119				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 23.06.

Table 33. Perceived Firewood Usage Chi-Square.

Crosstab

			Has there been an increase or decrease in firewood use?		
			Decrease	Increase	Total
Location in the Study Area	South Study Area	Count	50	16	66
		Expected Count	45.5	20.5	66.0
		% within Location in the Study Area	75.8%	24.2%	100.0%
	North Study Area	Count	19	15	34
		Expected Count	23.5	10.5	34.0
		% within Location in the Study Area	55.9%	44.1%	100.0%
Total		Count	69	31	100
		Expected Count	69.0	31.0	100.0
		% within Location in the Study Area	69.0%	31.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.144[b]	1	.042		
Continuity Correction [a]	3.267	1	.071		
Likelihood Ratio	4.049	1	.044		
Fisher's Exact Test				.067	.036
Linear-by-Linear Association	4.103	1	.043		
N of Valid Cases	100				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.54.

Table 34. Firewood and Fodder Collection by Time. Listed by 2003, 1998, and 1993.

Statistics

		How long does it take to get firewood (time)?	How long did it take to get firewood 5 years ago (time)?	How long did it take to get firewood 10 years ago (time)?	How long does it take to get fodder (time)?	How long did it take to get fodder 5 years ago (time)?	How long did it take to get fodder 10 years ago (time)?
N	Valid	43	40	43	27	22	27
	Missing	8	11	8	24	29	24
Mean		1.495	.749	2.405	2.100	1.089	2.970
Std. Error of Mean		9.94E-02	5.258E-02	.156	.293	.140	.314
Std. Deviation		.652	.333	1.023	1.522	.656	1.633

Table 35. Firewood and Fodder Collection by Distance. The are listed by 2003, 1998, 1993.

Statistics

		How long does it take you to cut firewood (distance)?	How long did it take you to get firewood 5 years ago (distance)?	How long did it take you to get firewood 10 years ago (distance)?	How long does it take you to get fodder (distance)?	How long did it take you to get fodder 5 years ago (distance)?	How long did it take you to get fodder 10 years ago (distance)?
N	Valid	35	27	25	37	26	26
	Missing	17	25	27	15	26	26
Mean		1.026	.694	1.396	1.105	.785	1.512
Std. Error of Mean		.172	.179	.207	.170	.184	.222
Std. Deviation		1.019	.932	1.033	1.033	.940	1.134

Table 36. Household Yearly Tree Usage.

Avg. Household Usage/ year (loads)	# of Households	*# of medium sized trees (30-50cm dbh) used/year*	*# of large sized trees (51-80cm dbh) used/year*
21	113	1017	452-565

Table 37. Household Gas Usage.

			GAS		
			1	2	Total
Location in the Study Area	North Study Area	Count	2	1	3
		% within Location in the Study Area	66.7%	33.3%	100.0%
	South Study Area	Count	9		9
		% within Location in the Study Area	100.0%		100.0%
Total		Count	11	1	12
		% within Location in the Study Area	91.7%	8.3%	100.0%

Table 38. 2003 Home and *goTH* Construction Chi-Square.

Crosstab

			Did you build your home or GoTH in the last year? No	Yes	Total
Location in the study area	South Study Area	Count	53	15	68
		Expected Count	48.9	19.1	68.0
		% within Location in the study area	77.9%	22.1%	100.0%
	North Study Area	Count	21	14	35
		Expected Count	25.1	9.9	35.0
		% within Location in the study area	60.0%	40.0%	100.0%
Total		Count	74	29	103
		Expected Count	74.0	29.0	103.0
		% within Location in the study area	71.8%	28.2%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.677[b]	1	.055		
Continuity Correction [a]	2.843	1	.092		
Likelihood Ratio	3.578	1	.059		
Fisher's Exact Test				.067	.047
Linear-by-Linear Association	3.641	1	.056		
N of Valid Cases	103				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.85.

Table 39. Local Perceptions of Timber Usage.

Crosstab

			Has there been an increase or decrease in timber use?		
			decrease	increase	Total
Location in the study area	South Study Area	Count	48	11	59
		Expected Count	49.5	9.5	59.0
		% within Location in the study area	81.4%	18.6%	100.0%
	North Study Area	Count	30	4	34
		Expected Count	28.5	5.5	34.0
		% within Location in the study area	88.2%	11.8%	100.0%
Total		Count	78	15	93
		Expected Count	78.0	15.0	93.0
		% within Location in the study area	83.9%	16.1%	100.0%

Table 40. Timber Tree Reforestation.

Crosstab

			Have you planted any timber trees on your land?		
			No	Yes	Total
Location in the study area	South Study Area	Count	44	23	67
		Expected Count	46.6	20.4	67.0
		% within Location in the study area	65.7%	34.3%	100.0%
	North Study Area	Count	27	8	35
		Expected Count	24.4	10.6	35.0
		% within Location in the study area	77.1%	22.9%	100.0%
Total		Count	71	31	102
		Expected Count	71.0	31.0	102.0
		% within Location in the study area	69.6%	30.4%	100.0%

Table 41. Fodder Collection Location.

			Where do you cut your fodder?		
			Community Forest	National Forest	Total
Location in the Study Area	South Study Area	Count	33	44	77
		% within Location in the Study Area	42.9%	57.1%	100.0%
	North Study Area	Count	4	34	38
		% within Location in the Study Area	10.5%	89.5%	100.0%
Total		Count	37	78	115
		% within Location in the Study Area	32.2%	67.8%	100.0%

Table 42. Household Fodder Usage T-Test.

Group Statistics

	Location in the Study Area	N	Mean	Std. Deviation	Std. Error Mean
How many loads do you need a day?	North Study Area	33	2.15	1.35	.23
	South Study Area	67	2.94	3.28	.40

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
How many loads do you need a day?	Equal variances assumed	14.945	.000	-1.325	98	.188	-.79	.60	-1.97	.39
	Equal variances not assumed			-1.699	95.817	.093	-.79	.46	-1.71	.13

Table 43. Daily Fodder Usage Chi-Square.

			Loads per day			
			0	1 or 2	3 - 12	
Location in the Study Area	South Study Area	Count	24	10	38	72
		Expected Count	17.5	19.5	35.0	72 0
		% within Location in the Study Area	33.3%	13.9%	52.8%	100.0%
	North Study Area	Count	2	19	14	35
		Expected Count	8.5	9.5	17.0	35 0
		% within Location in the Study Area	5.7%	54.3%	40.0%	100.0%
Total		Count	26	29	52	107
		Expected Count	26.0	29.0	52.0	107 0
		% within Location in the Study Area	24.3%	27.1%	48.6%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	22.365[a]	2	.000
Continuity Correction			
Likelihood Ratio	23.227	2	.000
Linear-by-Linear Association	.767	1	.381
N of Valid Cases	107		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.50.

Table 44. Household Fodder Tree Availability.

			Do you have fodder trees on you land?		
			no	Yes	Total
Location in the Study Area	South Study Area	Count	29	37	66
		% within Location in the Study Area	43.9%	56.1%	100.0%
	North Study Area	Count	16	17	33
		% within Location in the Study Area	48.5%	51.5%	100.0%
Total		Count	45	54	99
		% within Location in the Study Area	45.5%	54.5%	100.0%

Table 45. Household Fodder Availability Chi-Square.

Crosstab

			Do you have enough Fodder each Year? Not Enough	Enough	Total
Location in the Study Area	South Study Area	Count	27	27	54
		Expected Count	20.1	33.9	54.0
		% within Location in the Study Area	50.0%	50.0%	100.0%
	North Study Area	Count	5	27	32
		Expected Count	11.9	20.1	32.0
		% within Location in the Study Area	15.6%	84.4%	100.0%
Total		Count	32	54	86
		Expected Count	32.0	54.0	86.0
		% within Location in the Study Area	37.2%	62.8%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.162[b]	1	.001		
Continuity Correction [a]	8.744	1	.003		
Likelihood Ratio	10.933	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	10.044	1	.002		
N of Valid Cases	86				

a. Computed only for a 2x2 table

b. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.91.

Table 46. Perceived Household Fodder Availability.

			Has there been and increase or decrease in fodder species in the village?		
			Decrease	Increase	Total
Location in the Study Area	South Study Area	Count	49	11	60
		% within Location in the Study Area	81.7%	18.3%	100.0%
	North Study Area	Count	28	5	33
		% within Location in the Study Area	84.8%	15.2%	100.0%
Total		Count	77	16	93
		% within Location in the Study Area	82.8%	17.2%	100.0%

Table 47. Dogs in the Study Area.

			DOG		
			1	2	Total
Location in the Study Area	North Study Area	Count	13	4	17
		% within Location in the Study Area	76.5%	23.5%	100.0%
	South Study Area	Count	22	7	29
		% within Location in the Study Area	75.9%	24.1%	100.0%
Total		Count	35	11	46
		% within Location in the Study Area	76.1%	23.9%	100.0%

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APPENDICES

Appendix 1.

Formulae Used in Calculations

Quadrat Sampling Formulae

$$\text{Density} = \frac{\text{number of individuals}}{\text{Area samples}}$$

$$\text{Relative Density} = \frac{\text{density for a species}}{\text{total density for all species}} \times 100$$

$$\text{Dominance} = \frac{\text{total of basal area values}}{\text{area sampled}}$$

$$\text{Relative Dominance} = \frac{\text{dominance for a species}}{\text{total dominance for all species}} \times 100$$

$$\text{Frequency} = \frac{\text{number of plots in which species occurs}}{\text{total number of plots samples}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{frequency for a species}}{\text{total of frequency values for all species}} \times 100$$

Importance Value (sum) =

$$\text{relative density} + \text{relative dominance} + \text{relative frequency}$$

Importance Value (average) =

$$\frac{\text{relative density} + \text{relative dominance} + \text{relative frequency}}{3}$$

Appendix 2. Land Use Questionnaire.

LAND USE QUESTIONNAIRE
Please give short, correct answers to the below questions:

1) Do you have enough fodder for the year?
   enough | not enough | put a √ over the correct answer

2) How much do you need a day?

3) What kind of plants do you use for fodder?

4) Where do you cut your fodder? ~~Jungle~~ | Comm. For | Nat. For

5) Do you have fodder trees on your land? If so, What species?

6) Has there been an increase in fodder species in the village? Increased | Decreased

7) Where do you cut your firewood? Jungle | Comm. For | Nat. For

8) Now how long does it take to cut your firewood? 5 years ago? 10 years ago?

9) Now how long does it take to cut your fodder? 5 years ago? 10 years ago?

10) Have you seen trees planted in the last year? If so where?

11) Have you planted fodder trees on your land? Yes | No

12) Has there been an increase or decrease in firewood use? Increased | Decreased

13) How long is firewood purji open each year?

14) Did you build your home or Goth in the last year? Built | Not Built

15) If so, what trees and how many did you use?

16) Has there been an increase or decrease in timber use Increased | Decreased

17) Have you planted any timber trees on your land? Yes | No

18) How long is timber purji open each year?

19) What type of cattle do you own?

20) What type of goats do you own?

21) What type of field do you have?

22) How many months does your food last

3	4	5	6	7	8	9	10	11	12

23) Do you pay for your food? Yes No

24) Do you have to take out a loan to eat? Yes No

25) How long have you been planting mutter?

26) What other cash crops do you plant?

27) What type of fertilizer do you use?

28) Would you raise livestock if you had to stall feed them? Yes No

29) Has open grazing been stopped? If so how many years ago did it begin?

30) Do you have an income (diposable) each year? Yes No

31) Have you had an increase or decrease in income the last year? Increase
Decrease

32) How many days of labor do you do for money or grain?

THANK YOU FOR YOUR HELP! Brian H. Williams

Appendix 3. January 2003 Red Panda Pellet Measurements.

P.S. 33

Number	*Length*	*Width*
1	*31*	*16*
2	*34*	*14*
3	*35*	*15*
4	*35*	*15*
5	*28*	*12*
6	*32*	*13*
7	*30*	*18*
8	*29*	*15*
9	*31*	*17*
10	*32*	*11*
11	*30*	*12*
12	*20*	*14*
13	*25*	*10*
14	*27*	*11*
15	*38*	*15*
16	*39*	*17*
17	*20*	*16*
18	*32*	*15*
19	*26*	*14*
20	*35*	*10*
21	*17*	*11*
22	*32*	*15*
23	*26*	*12*

P.S. 34

Number	*Length*	*Width*
1	*53*	*18*
2	*28*	*11*
3	*21*	*9*
4	*31*	*10*
5	*31*	*9*
6	*30*	*11*
7	*30*	*8*
8	*31*	*11*

P.S. 35

Number	*Length*	*Width*
1	*31*	*10*
2	*31*	*11*
3	*30*	*8*
4	*33*	*11*
5	*35*	*11*
6	*32*	*11*
7	*38*	*15*
8	*30*	*12*
9	*42*	*11*
10	*35*	*12*
11	*40*	*9*
12	*31*	*10*

Appendix 3—*Continued*

P.S. 36 Number	Length	Width	P.S. 37 Number	Length	Width
1	47	16	1	46	20
2	41	10	2	37	18
3	31	8	3	50	20
4	35	11	4	35	21
5	34	9	5	48	18
6	40	11	6	45	18
7	33	7	7	45	18
8	43	10	8	30	8
9	34	12	9	35	15
10	41	11	10	35	15
11	31	11	11	32	18
12	33	10	12	40	20
13	34	9	13	30	10
14	40	11	14	30	9
15	29	10	15	46	18
16	32	9	16	25	10
17	45	16	17	30	11
18	29	10	18	51	20
19	35	8	19	32	10
20	41	9	20	35	11
21	34	12	21	35	10
22	36	10	22	30	10
23	21	11	23	45	20
24	31	11	24	35	18
25	35	14	25	40	20
26	36	13	26	45	20
27	21	11	27	30	11
28	41	10	28	45	15
29	30	11	29	45	16
30	29	8	30	40	20
31	18	7	31	35	20
32	42	13	32	45	20
33	46	11	33	30	10
34	30	9	34	25	10
35	22	10	35	35	10
36	35	11	36	32	11
37	32	13	37	31	9

Appendix 3—*Continued*

P.S. 36

Number	***Length***	***Width***
38	*25*	*9*
39	*30*	*10*
40	*31*	*11*
41	*31*	*10*
42	*32*	*11*
43	*33*	*11*
44	*26*	*12*

P.S. 37

Number	***Length***	***Width***
38	*25*	*10*
39	*35*	*10*
40	*43*	*11*
41	*45*	*18*
42	*35*	*11*
43	*35*	*10*

P.S. 38

Number	***Length***	***Width***
1	*48*	*15*
2	*37*	*18*
3	*41*	*18*
4	*35*	*16*
5	*22*	*18*
6	*32*	*15*
7	*35*	*16*
8	*35*	*17*
9	*40*	*18*
10	*40*	*16*
11	*30*	*15*
12	*45*	*18*
13	*30*	*16*
14	*35*	*18*
15	*30*	*18*
16	*40*	*18*
17	*35*	*16*
18	*40*	*15*
19	*20*	*10*
20	*25*	*10*
21	*45*	*15*
22	*50*	*15*
23	*44*	*16*
24	*35*	*11*
25	*30*	*18*
26	*40*	*15*
27	*40*	*16*
28	*40*	*18*

Appendix 4. Red Panda Sign Plot Importance Value Indicies.

Red Panda Sign Plot Importance Value Index.

Tree species	Relative Density	Relative Dominance	Relative Frequency	IVI SUM	IVI AVG
Lithocarpus pachyphylla	14.01	28.13	4.61	47.01	15.58
Litsea sericera	20.20	18.51	6.29	45.15	15.00
Magnolia campbellii	2.18	3.03	24.11	29.23	9.77
Ilex dipryena	0.06	2.03	23.90	26.34	8.66
Machilus edulis	14.03	3.62	1.89	20.14	6.51
Viburnum erubescens	7.78	4.49	3.98	16.31	5.42
Betula utilis	7.57	3.60	1.89	13.27	4.35
Litsea khasyana	4.23	7.42	0.21	12.42	3.95
Rhododendron grande	2.98	5.32	1.68	10.24	3.33
Symplocos theifolia	2.80	2.71	4.19	10.41	3.23

Panda sign plot Importance Value Index by altitude.

2400m-2600m		**2600m-2800m**		**2800m-3000m**	
Tree species	**IVI Sum**	**Tree species**	**IVI Sum**	**Tree species**	**IVI Sum**
Lithocarpus pachyphylla	70.57	*Litsea sericera*	49.05	V. erubescens	43.37
Litsea sericera	59.79	*Viburnum erubescens*	33.90	*S. theifolia*	41.29
Machilus edulis	39.84	*L.pachyphylla*	33.51	*Ilex dipyrena*	24.92
Litsea khasyana	22.59	*Rhododendron grande*	30.37	*H. excelsum*	21.67
Betula alnoides	13.96	*A. himalaica*	21.80	*Acer spps.*	20.71
Magnolia campbellii	13.36	*B. utilis*	16.96	*Piptanthus nepaulensis*	17.42
Acuba himalaica	11.58	*Symplocos ramosissima*	16.17	*M.campbellii*	15.75
		Schefflera impressa	13.27	*R. arboreum*	15.36
		Lindera neesiana	12.80	*R. falconeri*	14.27
		Acer sp.	12.60	*L. neesiana*	13.17
		R. arboreum	11.58	*Saurauia griffithii*	11.75
		Hymenodictyon excelsum	11.56		
		Symplocos theifolia	11.46		

Appendix 4 – *Continued*

Dominant Shrubs

2400m-2600m	**2600m-2800m**	*2800m -3000m*
A.maling	*A.maling*	*A. Maling*
Daphne bholua	*D. bholua*	*A. aristata*
		V. erubescens
		D. bholua

Appendix 5. Random Plot Importance Value Indicies.

Random Plot Importance Value Index

Tree species	Relative Density	Relative Dominance	Relative Frequency	IVI Sum	IVI Avg.
Litsea sericera	11.55	13.92	10.55	36.13	12.14
Lithocarpus pachyphylla	8.56	16.44	10.55	36.11	12.22
Rhododendron arboreum	13.94	13.58	3.69	31.19	10.14
Symplocos theifolia	7.42	6.82	6.07	20.43	7.32
Eurya acuminata	8.80	4.99	5.28	19.30	6.27
Lindera neesiana	4.19	3.53	6.07	14.22	5.39
Machilus edulis	4.58	3.25	5.54	13.19	4.48
Magnolia Campbellii	2.81	4.29	3.96	11.08	4.55
Lyonia ovalifolia	4.86	2.79	2.90	11.10	4.35
Acer sp.	2.51	2.91	5.01	10.06	3.21

Appendix 5 – *Continued*

Random Plot Importance Value Index by Altitude

2400m -2600m		**2600m -2800m**		**2800m -3000m**	
Tree species	IVI Sum	Tree species	IVI Sum	Tree species	IVI Sum
Lithocarpus pachyphylla	35.15	*L. sericera*	57.60	*R. arboreum*	74.19
Eurya acuminata	34.93	*L. pachyphylla*	43.76	*Viburnum erubescens*	39.17
Litsea sericera	26.03	*R. arboreum*	29.99	*S. theifolia*	37.18
Symplocos theifolia	24.92	*Magnolia campbellii*	19.82	*L. neesiana*	26.93
Rhododendron arboreum	22.20	*Hymenodictyon excelsum*	18.82	*B. utilis*	17.07
Machilus edulis	20.20	*Rhododendron grande*	17.54	*Saurauia griffithii*	15.70
Quercus lamellosa	16.80	*Lindera neesiana*	16.82	*Osmanthus sauvis*	13.11
Lyonia ovalifolia	16.54	*Betula utilis*	11.34	*Acer sp.*	11.60
Litsea khasyana	13.39				
Acer sp.	11.31				

Dominant Shrubs

2400m-2600m	**2600m-2800m**	**2800m-3000m**
A. maling	*A. maling*	*A. maling*
V. erubescens	*V. erubescens*	*V. erubescens*
Pittosporum nepalense	*Daphne bholua*	*D.bholua*
Morrus indica		

Appendix 6. <u>Plant List.</u> All plant speices encountered in the microhabitat survey.

No.	Nepali Name	Scientific Name	Poulnin & Stainton
Trees			
1	Akhane	*Populus ciliate*	*1301, d.505*
2	Angeru	*Lyonia ovalifolia*	*817, pl.76*
3	Asare	*Viburnum erubescens*	*604, pl.52*
4	Aule Bante	*Lithocarpus elegans*	*1282, d.507*
5	Aule Gagune	*Saurauia nepaulensis*	*219, pl.19*
6	Aule Ghans	*Antidesima bunius*	*p116 TNB*
7	Aule Timur	*Zanthoxylum hamiltonianum*	p.29 TNB
8	Bajarat	*Quercus lamellosa*	*1285, d.508*
9	Balu Chinde	*Schefflera impressa*	*p71 TNB*
10	Bhote pati	*Elscholtzia fruticosa*	*1169, pl100*
11	Bhus pate	*Betula utilis*	*1272, d506*
12	Chandan	*Daphniphyllum himalayense*	*p116 TNB*
13	Chimal	*Rhododendron grande*	*794*
14	Dabdabe	*Symplocos ramosissima*	*895*
15	Dudhilo	*Ficus nemoralis*	*p125 TNB*
16	Falat	*Quercus glauca*	*1283, d.508*
17	Ghurbis	*Leucosceptnum canum*	*1105, pl 103*
18	Gogai Champ	*Magnolia campbellii*	*72, d446*

Appendix 6 – *Continued on the next page*

Appendix 6 – *Continued.*

No.	Nepali Name	Scientific Name	Poulnin & Stainton
19	Jhingane	*Eurya acuminate*	*216, d.453*
20	Kali Kath	*Aucuba himalaica*	*p73 TNB*
21	Kapasi	*Acer spps*	*284, d.456*
22	Karsu	*Quercus semecarpifolia*	*1288, d.509*
23	Katus	*Castanopsis hysterix*	*1279, d.507*
24	Kaulo	*Machilus edulis*	*p106 TNB*
25	Khanakpa	*Evodia fraxinifolia*	*p27 TNB*
26	Kharane	*Symplocos theifolia*	*893, d.485*
27	Kholme	*Symplocos pyrifolia*	*NA*
28	Lali Gurans	*Rhododendron arboreum*	*797, pl.74*
29	Lampate	*Litsea khasyana*	*p110 TNB*
30	Larim	*Piptanthus nepaulensis*	*321, pl.27*
31	Bante	*Lithocarpus pachyphylla*	*1281, d.507*
32	Lisse	*Ilex dipyrena*	*267, pl.23*
33	Lokta	*Daphne bholua*	*1217, pl.108*
34	Loth Salla	*Taxus baccata*	*1324*
35	Pahele	*Litsea salicifolia*	*p110 TNB*
36	Panch pate	*Vitex heterophylla*	*p99 TNB*
37	Seti Kath	*Hymenodictyon excelsum*	*p76 TNB*
38	Silinge	*Osmanthus suavis*	*909, pl.86*
39	SiSi	*Lindera pulcherrima*	*1214, pl.109*
40	Timur	*Zanthoxylum armatum*	*262*

Appendix 6 – *Continued* on the next page

Appendix 6 – *Continued.*

No.	Nepali Name	Scientific Name	Poulnin & Stainton
41	Korlinga	*Rhododendron falconeri*	*793, pl.76*
42	Lahare cunitro	*Stachyurus himalaicus*	*220, pl.20*
43	Leka Timur	*NA*	*NA*
44	Tenga	*Sorbus cuspidata*	*432, pl.9*
45	Lali	*Machilus parvifolia*	*p107 TNB*
46	Cutro	*Mahonia nepaulensis*	*86, pl.10*
47	Leka Gogune	*Saurauia griffithii*	*p20 TNB*
	Shrubs, Herbs and Bamboo		
48	Malingo	*Arundinaria maling*	*1494, p 139 TNB*
49	Gagleto	*Elastostema sessile*	*NA*
50	Jale Kada	NA	NA
51	Kali gedi, klaksi	*Gaultheria nummularoides*	*820*
52	Khursani Gas	*Pittosporum nepalense*	p16 TNB
53	Ningalo	*Arundinaria aristata*	*p139 TNB*
54	Putali	*Rubus laenatus*	NA
55	Grass	*Polypogon fugax*	*NA*
56	Fern	*Pteridium aquilinum*	*p144 TNB*
57	Bhui ainselu	*Fragaria nubicola*	*439, pl.36*
58	Kimbu	*Morrus indica*	*p127 TNB*
59	Lahare tenga	*Actinidia stringosa*	*p19 TNB*
60		*Primula irregularis*	*875, pl.83*

Appendix 6 – *Continued on the next page*

Appendix 6 – *Continued.*

No.	Nepali Name	Scientific Name	Poulnin & Stainton
61	Kroma	*Potentilla fulgens*	*449, pl.38*
62	Titepati	*Artemisia vulgaris*	*p80 TNB*
63	Kurkure jhar	*Lippia nodiflora*	*NA*
64	bokre phul	*Gnaphalium affine*	*647, d.475*

* All Nepali Names are taken from *Dictionary of Nepalese Plant Names*, Shrestha, K. 1998. Kathmandu, Nepal: Mandala Book Point.

* TNB stands for *The Trees of North Bengal: Including shrubs, woody climbers, bamboos, palms, and Tree ferns.* Cowan, A.M. and J.M., Cowan. 1929. Reprint 1993. Allied, Dheradhun.

RESEARCH PERMITS

Note No. 178

The Embassy of the United States of America presents its compliments to the Ministry of Foreign Affairs of his Majesty's Government of Nepal and has the honor to inform the Ministry of the arrival in Nepal of Mr. Brian H. Williams, a Fulbright Student, with the United States Educational Foundation. The United States Educational Foundation functions under the auspices of this Embassy. Mr. Williams will be arriving in Nepal on or about first week of September 2002. His passport details are as follows:

Name: Mr. Brian H. Williams
Passport No.: 153444386
Issued: Washington D.C., October 12, 1995
Expiry Date: October 11, 2005

The Embassy of the United States of America further has the honor to request the Ministry to provide Mr. Williams with appropriate Nepalese gratis visa for 15 days upon his arrival at the airport.

The Embassy of the United States of America avails itself of this opportunity to renew to the Ministry of Foreign Affairs the assurances of its highest consideration.

His Majesty's Government
Ministry of Foreign Affairs

Embassy of the United States of America,
Kathmandu, August 13, 2002

EMBASSY OF THE UNITED STATES OF AMERICA
KATHMANDU

श्री अध्यागमन विभाग
प्रदर्शनीमार्ग ।

विस्तृत व्यहोरा पत्रबाट
अवगत गर्नु भै अनुरोधानुसार
त्रि. वि. स्थित अध्यागमन कार्यालयबाट
नियमानुसार निःशुल्क (GRATIS) भीसा १५ दिन
उपलब्ध गराई दिने व्यवस्था हुन
सिफारिश गरिन्छ ।

13 AUG 2002

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San José State
UNIVERSITY

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To: Brian Williams
1063 Morse Avenue
Sunnyvale, CA 94089

From: Pam Stacks, Pam Stacks
Interim AVP, Graduate Studies & Research

Date: November 18, 2003

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"Status of the Red Panda in Ilam, Nepal."

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Pam Stacks, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subjects portion of your project is in effect for one year and data collection beyond November 18, 2004 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

cc: Dr. Gary Klee